NEW ZEALAND FORESTRY.

PART I.

BY

D. E. HUTCHINS, I. F. S.

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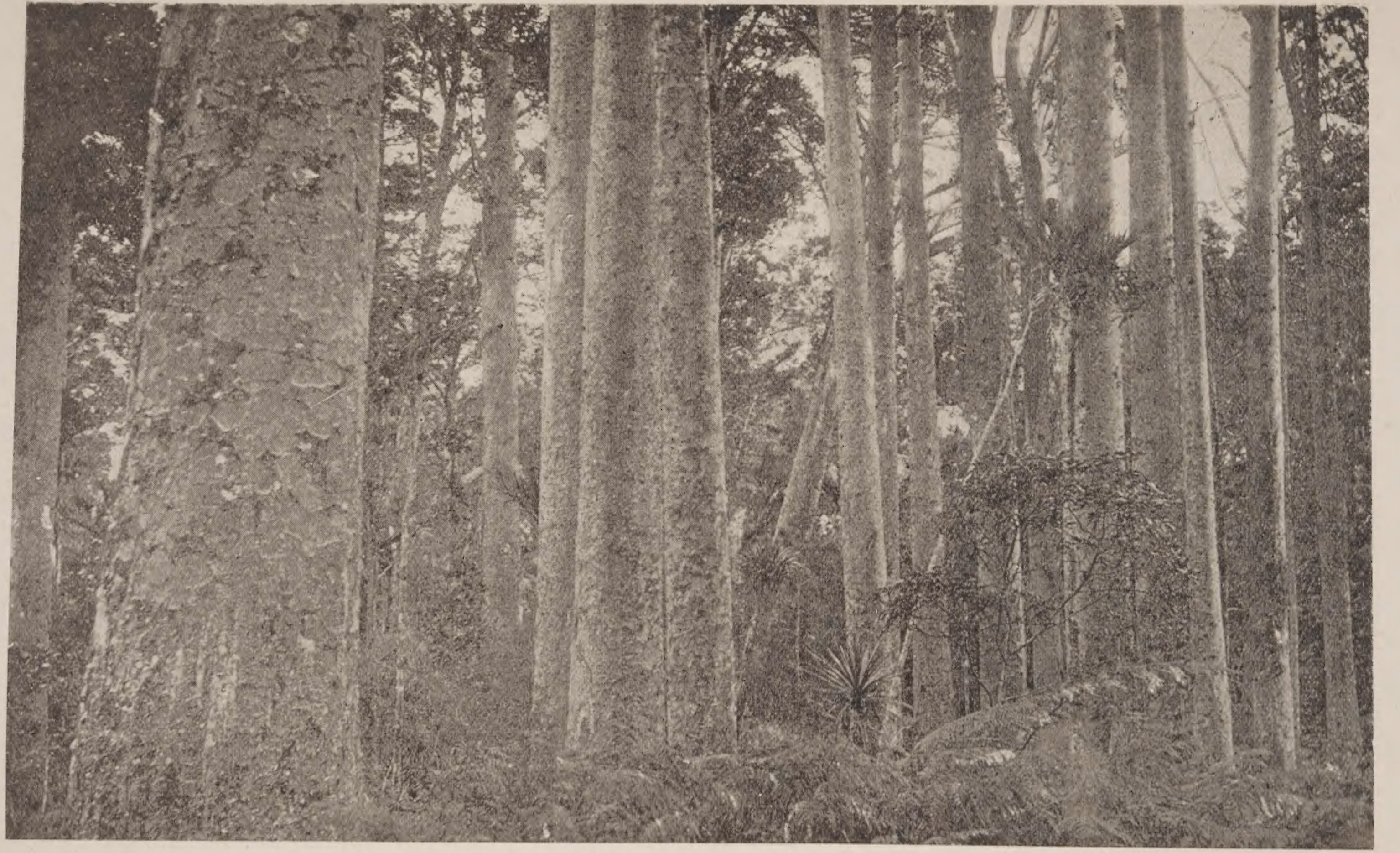

"The noble Kauri Trees" (Darwin).

Kauri forest of all ages at Matakohe. The old tree shows the resin dripping from the base of the trunk.

Parker-Lamb Timber Co.]

[*Frontispiece.*

DEPARTMENT OF FORESTRY,
NEW ZEALAND.

NEW ZEALAND FORESTRY.

PART I.

KAURI FORESTS AND FORESTS OF THE NORTH
AND
FOREST MANAGEMENT.

BY

D. E. HUTCHINS, I.F.S.

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REPORT ON NEW ZEALAND FORESTRY.

Department of Forestry, Wellington, 30th October, 1919.

SIR,—

I have the honour to submit herewith a report by Mr. D. E. Hutchins on New Zealand forestry.

Mr. Hutchins graduated at L'École Nationale des Eaux et Forêts, Nancy, France, in 1872, and afterwards joined the Indian Forest Service. After serving ten years in India he joined the Forest Department of Cape Colony, where he remained for twenty-three years. As Conservator of Forests in Cape Colony Mr. Hutchins's work has been highly praised by eminent forest authorities; and his reputation was such that he was selected by the Colonial Office to organize a Forestry Department for British East Africa. He was also chosen by the Colonial Office to report on the forests of Cyprus.

In 1894 he received a medal from the Society of Arts, London, for a paper formulating for the British Isles a scheme of national forestry, which was substantially the same as that which has during the last year been adopted by the British Government.

Mr. Hutchins came to Australia in 1914 to attend the meeting of the British Association. After the meeting he remained in Australia, and wrote a report on Australian forestry for the Western Australian Government.

He came to New Zealand in 1916, and has already written a report on the Waipoua Kauri Forest.

In the present report Mr. Hutchins has dealt with his subject in a most comprehensive and exhaustive manner; and I need hardly say that the opinions of a man of such wide and varied experience, and who at the same time is without local prejudices, are deserving of the most thoughtful consideration.

Mr. Hutchins has been afforded every facility to fully express his views and criticism, regardless as to whether the Departments concerned are in agreement with some of his conclusions or are satisfied with the data on which some of those conclusions are founded.

I have, &c.,

E. PHILLIPS TURNER, Secretary.

The Hon. Sir F. H. D. Bell, K.C.M.G., K.C.,
Commissioner of State Forests, Wellington.

PREFACE.

In marshalling the facts here set forth a narrative style has been attempted. This, owing to the many branches in certain subjects, has led to some small repetitions and to many cross-references in the index. Thus it may be useful to first read that which was written specially for the busy man, the "Recapitulation," page 178. This gives a brief summary of the more important facts, except those relating to the relative growth of native trees, a subject which stands sufficiently clearly by itself in these pages; and is, moreover, discussed in a separate paper (New Zealand Institute, 1920).

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NEW ZEALAND FORESTRY.

PART I.—THE KAURI FOREST.

THE LARGEST TIMBER-YIELDING TREE IN THE WORLD: ITS CLIMATE, GROWTH, TIMBER, AND RESIN.

> "The noble Kauri trees, the most valuable production of the (North) Island."
> —CHARLES DARWIN.

THE Kauri* tree in New Zealand was discovered about the time that scientific forestry in Europe had begun to show clearly what it could do towards its modern development—Germany getting £24,000,000 yearly out of its cultivated forests, and paying £7,000,000 in wages to a population not far short of that of the whole of New Zealand, a population settled permanently on the soil and engaged in working the forests: this, too, with timbers inferior to New Zealand timbers and averaging only half the price on the local markets.

Early in 1800 a trade in Kauri spars sprang up between Sydney and the Bay of Islands. By 1810 the value of Kauri was established in Australia. The "Boyd," whose crew were massacred and the ship blown up by the Maoris, was calling for a cargo of spars for the Cape of Good Hope when the catastrophe happened. Earle relates that in 1827 the big ship "Harmony," of London, was loaded up *in a few days* at Hokianga with Kauri spars, while at the same time there was a party of Scotch pit-sawyers assisted by Natives on shore. In South Africa there are similar parties of white pit-sawyers assisted by Natives to this day.

The Totara was the favourite tree of the Maoris, perhaps because it was more easily hollowed with their Greenstone axes than the solid, sound Kauri. But the Kauri leapt into fame as soon as it was discovered by Europeans. Samples of the timber were sent to England and attracted much attention. In 1820 the Admiralty despatched two naval store-ships to obtain cargoes of Kauri for experimental purposes (Cheeseman). Kauri timber proved so good that some years later Laslet, the famous constructor to the Admiralty and author of the oft-quoted classic on timber, came himself to New Zealand to see the famous timber on the spot. This was before the British flag was hoisted.

---

* In accordance with a growing practice the specific part of botanical names is spelt uniformly with a small letter; popular names with a large letter. The author of the botanical name and the botanical name itself are omitted unless really necessary for identification. Reference lists of common and botanical names (from Cheeseman's "Manual of the New Zealand Flora") will be found under the heading "Native Trees," in Part II.

The French Example.—The French discovered Kauri timber, but, sadly for the forests, it was not their flag that was destined to wave over them. It is safe to say that if Du Fresne's countrymen had had the handling of the Kauri forests they would by now have been a national asset equal in value to anything the war can cost the Dominion. The proof of the pudding is in the eating! The French colony of Algeria is in exactly the same latitude as the cream of the Kauri forests—a country where the Insignis-pine grows as fast as and, I should say, somewhat more healthily than in New Zealand, and where many more specimens of high-speed Eucalypts display their somewhat deceptive charms to the tree-planter! The French take these trees for what they are worth—they have no illusions about them! They preserve the native forests.

Algeria is far from having a good tree-growing climate like northern New Zealand; the Algerian forests are not half the value of the Kauri forests, and there is not in all Algeria a timber-tree which has even one-third the value of a Kauri tree. Nevertheless the French have demarcated the forests, preserved all that was worth preserving, and are managing the demarcated forest now with a technically-trained Forest Department as good as that in France—and there is no better!

If France had inherited the Kauri Forests.—If a pioneer Englishman had discovered valuable coal-mines and opened them up; if an unskilled race had come afterwards and burnt the coal-mines, making clumsy attempts at working them, the feelings of the Englishman would match sentiments I have heard expressed by French foresters regarding the destruction of the Kauri forests! This much is certain: the loss of the coalfields would have been a one-crop loss; the loss of the Kauri forests is a perpetual-crop loss.

Count de Vasselot (p. 45, "Waipoua Kauri Forest") always hoped to visit the Kauri forests, but when he retired from the service his chateau in Normandy prevailed over foreign travel.

I did my forest training in France. French is to me a second mother-tongue. I know French sentiments in forestry intimately, and have no hesitation in asserting that if the French had inherited the Kauri forests they would by now have been in possession of national Kauri forests easily able to meet the interest on any possible New Zealand war debt. The £3,500,000 that Australia may soon be sending away yearly to the Northern Hemisphere for imported softwood would be coming to New Zealand; and if only a million acres of good Kauri forest had been kept there would have been a great and permanent Kauri industry, with some 13,350 families settled permanently on the land as forest workers, besides a large number employed in sawing and transport. That million* acres would be supporting a population at the rate of one family per 37½ acres, and that million acres would besides be paying some £5,000,000 net profit yearly to the Consolidated Fund. The next generation would see that £5,000,000 risen to £10,000,000, and a few generations ahead there would be a certain prospect of a rise to some £20,000,000. Is there any other million acres in New Zealand that can show an equal result? Charles Darwin's statement was correct. The figures in support of this calculation will be found at p. 95, "Balance-sheet of a Normal Kauri Forest."

Foresters would have come with the first officials from France, and the present and prospective value of the Kauri forests would have become early known. It is not conceivable that any form of French Government would have tolerated that incredible waste of natural resources that has been going on unchecked in New Zealand for a hundred years in the destruction of the Kauri forests. There has been a national obsession in the matter for which it would be hard to find many historical parallels. Perhaps the belief in witchcraft may be one!

---

* Supposing they worked, as in Europe, half the year on small farms and half the year in the forest.

Some one said Kauri grew slowly, as some one always does say valuable trees grow slowly. It took seventy years before any one put the matter to the test, and Cheeseman's investigation is still not generally known. Forty-one years ago Captain Campbell-Walker said categorically, "Kauri is a fast-growing tree." But (to quote from a book of sober statistics that has had a steady sale in New Zealand for the last eight years), "In spite of all warnings and expert advice, New Zealand has continued this policy of national profligacy with little remission up to the present day. Half-hearted attempts have been made to arrest it." ("New Zealand in Evolution." Whitcombe and Tombs.)

STATE FORESTS TO PAY THE COST OF THIS WAR.

The world-wide calamity of this war has been thrust on both English and French. The heavy after-burden has to be borne, and the Dominion can no longer afford to disregard the public asset of national forests. If we do not succeed in making our enemies pay for their war, the next best thing to do is to take a leaf out of their book and pay for the war eventually with State forestry in New Zealand. Says the occupant of the Chair of Forestry at the Oxford University, my old friend Sir William Schlich, "It is most depressing to hear of the rapid destruction of the Kauri forests of New Zealand. . . . Surely it is great extravagance to destroy a source of revenue like that derivable from the Kauri forests." ("Manual," vol. 1.) That is true, but it is not difficult to see how this extravagance, this disregard of the future, came about. When the Kauri forests were first worked under an ordered Government nothing was known of scientific forestry outside France and Germany. The great national forest estates now pouring their millions yearly into the State coffers of those countries had small beginnings. Much of the timber was valueless for want of roads; that which could be put on the market actually *only averaged about 1d. a cubic foot* after logging and bringing to a roadside! (U.S.A. Bull. 83.) State forestry offered little promise of surplus millions in those days. But France and Germany persevered. They made small profits, but they stuck to the forest "working-plans," which themselves pointed very clearly to better times ahead. Then the other European nations joined in. It was a gradual process. The national forests paid their way, supported a large population on the soil, and were popular. They found the healthiest of work for the needy, the best of sport for the leisurely. They were ever slowly improving. Wherever the forest officers saw an opening for a new market they made a new road and paid for it with the timber got out. Gradual as was the improvement of the forests, it never flagged. The net forest revenue per acre per year of the Kingdom of Saxony increased sevenfold in ninety-six years. Thus there was no startling discovery about State forestry in Europe, a discovery which could reach New Zealand and arouse attention. Again, home rule, which practically stopped the alienation of good forest in South Africa, had, alas, no such effect in New Zealand.

It has taken the calamity of this great war to rouse attention to the fact that careful demarcation and judicious redemption may still restore a large part of the Kauri forests. Kauri seed remains long dormant in the ground; Kauri seedlings endure most evils short of being burnt, and fire-protection is so easy that it will go with forest-development and scarcely be thought of. The task now before the country is to build up national forest estates by raking into the national net every acre of Kauri forest or land where Kauri forests can profitably be restored!

Two instances where this can be done have come to my notice during the past year, and have been represented officially—(1) Mr. McLeod's Terai-o-Rahiri, and (2) a large part of the Tutamoe Forest, where, according to the records, *grew the largest timber-yielding tree that has ever grown in the world*, the great Kauri tree called "Kairaru" by the Maoris. The first is Maori land obtainable at quite a moderate price—a trifle compared to its value as cultivated Kauri forest. The second is Government land, part of a larger forest area redeemable on easy terms.

HALF-MILLION ACRES OF KAURI LAND—COROMANDEL AND HOKIANGA.

Kauri, with half a million acres of demarcated forest, could still pay the cost of the war—perhaps twice over.

An energetic policy of demarcation and redemption, *put in force at once*, would find half a million acres of restorable Kauri forest without much difficulty. It would mean little more than sixteen times the area of the Waipoua Forest. From inquiries which I have made at the Lands Department and a study of the coloured land-tenure map (May, 1916) issued by the Lands Department, it seems clear that demarcation and redemption can certainly secure half a million acres of restorable Kauri forest between the following two areas:—

(1.) *Coromandel Peninsula.*—The occurrence of much restorable Kauri forest here is mentioned at page 55, "Waipoua Kauri Forest." Here at Cape Colville and on the eastern coast side was the cream of the Kauri in Kirk's time. The mountainous character of the area is well known. It is an ideal forest area, with its mountain-streams, bays, and inlets from which timber can be taken by sea across the water to Auckland. The land is mostly Native or vacant Crown land. Auckland should look on the Coromandel Peninsula as the sheet-anchor of its future Kauri timber and Kauri "gum" trade. (See Plate I.)

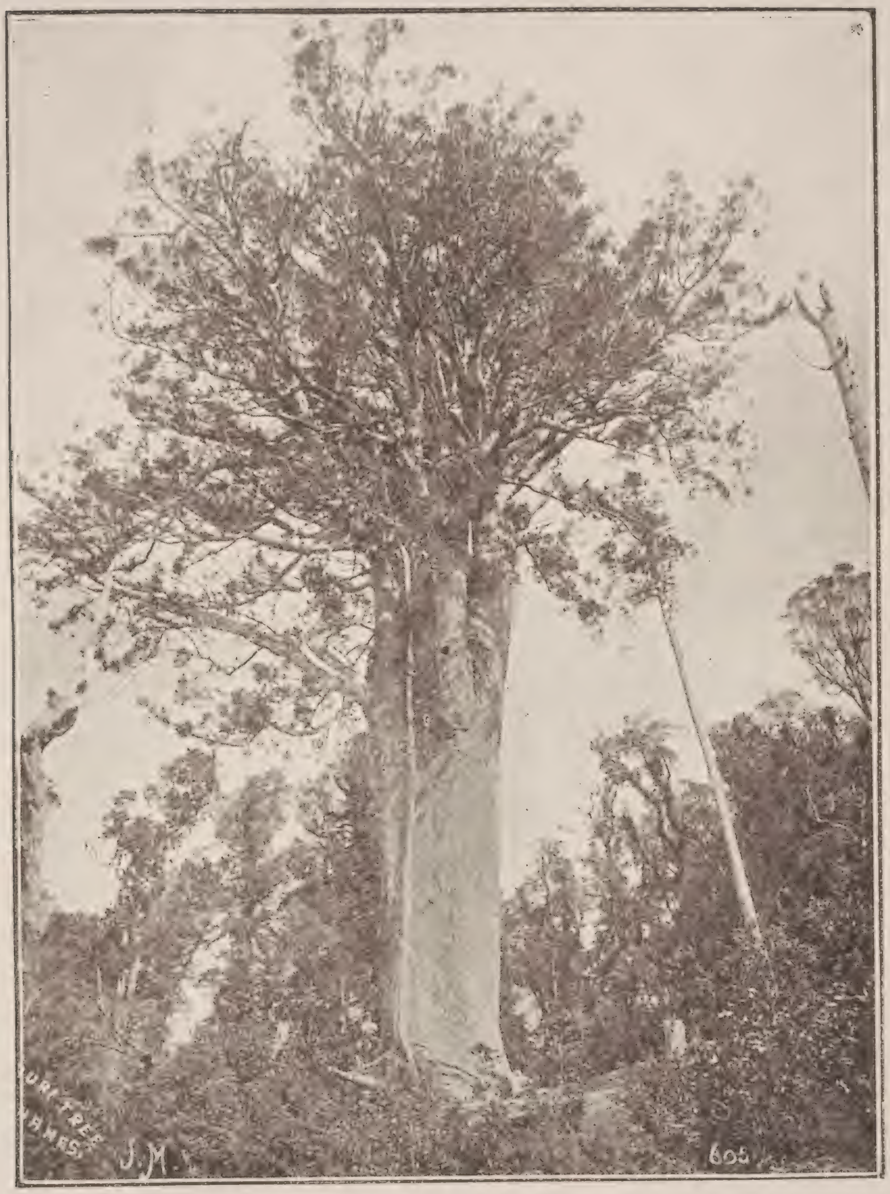
Great Barrier Island is naturally in the same position as the mountainous Coromandel Peninsula; but, unfortunately, most of the land is freehold. It should be redeemed as far as possible.

(2.) *Hokianga (North and East of the Waipoua and Warawara Forests).*—The large area of demarcatable forest here is referred to in "Waipoua Kauri Forest," pp. 51–52. The bulk of the land is "public reserve," "Native," or "endowment" land, Native land predominating.

In these two areas there lies about a million acres of more or less available land, so that the securing of at least half of it for national forestry seems assured.

This half-million acres of forest, after being put into order, is calculated eventually to provide about four times the timber in perpetuity that came temporarily to the Auckland sawmills from the wild forest (p. 82).

Plate I.



To restore a vanishing Industry. A Kauri Tree of the Coromandel Peninsula.

A typical Kauri tree, eastern coast, about 14 ft. diameter and 55 ft. bole. The trunk is slightly thicker below the crown-bulge than above the root-bulge.

Photo, J. Martin.] [*To face p. 4.*

As appears below, £10 net per acre per year can be confidently expected from the cultivated Kauri forest of the future. This is a conservative estimate founded on scrupulously moderate figures. 500,000 acres at £10 would put £5,000,000 yearly into the State coffers of New Zealand, which is better than the Prussian figure of £4,500,000 (p. 186). £5,000,000 capitalized at 4 per cent. represents £125,000,000. This would cover the cost of the war, it may be hoped, nearly twice over.

Furthermore, half a million acres of Kauri forest cultivated as in Europe would find much forestry work now for returned soldiers, and eventual permanent land-settlement exceeding all that has been effected up to date, under the closer Land for Settlement Acts since 1892, and the Land Settlement Finance Act of 1909.* Half a million acres of cultivated Kauri forest would mean some 6,666 families earning good wages, settled permanently on the soil (pp. 89, 160), together with many engaged in small farming and in the milling and transport of the timber. It would mean support to all the wood-using industries and some lowering of the cost of house-building and house-rents. These things are to be obtained by nothing more novel or hazardous than following the colonial policy of the French in the latitudes of the Kauri forests on the Mediterranean!

Details of the Kauri forest net revenue and of employment and settlement will be found under "Balance-sheet of a Kauri Forest" (p. 95).

Kauri the Old-established Safe Tree.—National money put into Kauri forestry is a safe investment. It is difficult to realize what an old-established institution the Kauri tree is in New Zealand! Even the tree's geological age is enormous. Buried forest occurs in various localities; perhaps that at Papakura, near Auckland, is the best-known. And over all hangs the glittering prospect of the Kauri-resin industry eclipsing that of Gascony, with the upgrowth of the restored Kauri forests, and the advent of a settled population—*la richesse de ce pays-ci*, as the French curé said to me. ("Aus. Forestry," p. 259, Brit. Assoc., 1914.)

MNEMONIC.

Half a million acres of restorable Kauri
Will twice pay the war debt. No Eastern *houri*
Could do more for an overtaxed man!
It may settle near twice the men on the land
That the two Land Acts,† working hand-in-hand,
Did up to the outbreak of war—
Five thousand seven hundred and eighty.

CULTIVATED FORESTS: A MILLION OF POPULATION.

Cultivated forests as in Europe if established in New Zealand would eventually support a population about equal to the whole present population. Taking the European standard of 25 per cent. forest—the standard in the most industrial and best populated parts of Europe—New Zealand would require about 16,000,000 acres of national forest. The Japanese, with a land of mountainous volcanic islands like New Zealand, are taking a forest proportion higher—viz., 65 per cent.; but let us now consider the European proportion. 16,000,000 acres at an average of five persons per family, and 200 acres of forest per family, would mean with the resulting sawmill employment a population of some 500,000 souls. Working half on small farms and half in the forest, as in Europe, the population supported would be some 1,000,000. The country would be opened up with roads and parcelled out into farms and demarcated forest, the latter enclosing small valley farms suitable to *la petite culture* (home farming) scattered throughout the demarcated forest areas.

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* 5,780 settlers, up to the outbreak of war, is the total under the two Acts. "Closer Settlement in New Zealand" by the Under-Secretary of Lands, International Institute of Agriculture, Rome, 1916.

† 1892 and 1909.

I here take a general average of 200 acres of forest to support a family. But if we take European figures the employment in valuable forest, such as Kauri forest, would be at the rate of one family per 75 acres. Probably about 200 acres per family may be taken as a general average of employment when once New Zealand forests were got into order as cultivated forests. Further, with the powerful sun of New Zealand latitudes, the ample rainfall, and generally rich soil, together with the unique timber market of the Southern Hemisphere, both forest production and population may be expected to eventually rise higher than in Europe. It seems quite reasonable to expect that with its normal area of 16,000,000 acres of national forest there will eventually be a permanent forest population in New Zealand of between 1,000,000 and 2,000,000 souls. The small English war-insurance forestry scheme of 2,000,000 acres only (with 1,770,000 as a war precaution) is calculated to permanently settle on the land 25,000 families—say, 125,000 souls—or in the proportion of one man per 71 acres.

THE ORIGINAL KAURI FOREST.

The parliamentary return of 1873 puts the total area of forest in the Auckland Province in 1830 at 4,000,000 acres. This, however, referred to forest that happened at that time to carry millable timber It was only timber that counted in those days.

If one takes the area of New Zealand between latitude 35° and latitude 37° 30′, and deducts a little less than one-third for mountainous ground above 1,500 ft. elevation, where Kauri is absent or rare, and for areas where from fire, swamp land, or other causes the forest was either absent or was without Kauri, the resulting area is about *four million acres*. It seems probable that there was between three million and four million acres of Kauri forest confronting the Englishman when he entered into possession of New Zealand. The Maoris, says Mr. Elsdon Best, destroyed little forest. They had no game to drive or hunt in the open grass lands, like the Tasmanian "blacks"; and the forest, except in a few dry parts of New Zealand, is not easily burnt, except when being worked.

Ninety-two years ago Earle, the artist, traversed the Kauri forests four times from coast to coast. He describes the fine character of the forest in these words: "We travelled through a wood so thick that the light of Heaven could not penetrate the trees that composed it. They were so large and so close together that in many places we had some difficulty to squeeze ourselves through them. . . . Not a gleam of sky was to be seen: all was a mass of gigantic trees, straight and lofty, their wide-spreading branches mingling overhead, and producing throughout the forest an endless darkness and unbroken gloom." (A. Earle, "Nine Months in New Zealand," 1827.)

Eight years afterwards, in 1835, the great Darwin visited the Kauri forest near the Bay of Islands. He did not fail to notice the peculiarity of the Kauri tree—its trunk with little or no taper. He speaks prophetically of "the noble Kauri trees, the most valuable production of the Island," for there is scarcely the remotest chance of any production rivalling economically that of a well-ordered Kauri forest growing on its own poor soil. Then he adds, "These trees are remarkable for their smooth cylindrical boles, which run up to a height of 60 ft. and even 90 ft. *with a nearly equal diameter* and without a single branch. *The forest was here almost composed of the Kauri, and the largest trees from the parallelism of their sides stood up like gigantic columns of wood.*" ("Voyage of a Naturalist.")

Dr. Hochstetter, writing in 1867, gives various interesting details regarding the Kauri forests of that time; and Kirk, in 1889, the account of the Kauri forests in his "Forest Flora."

Said the late Mr. Colenso, "There are few sights more impressive or grander than an untouched forest of this stately tree; few more impressive of misery and devastation than a worked-out and abandoned one." ("Botany of North Island," p. 40.)

In 1885 Mr. Percy Smith, Surveyor-General, estimated the area of Kauri likely to pay for working at 138,470 acres. It must be remembered that owing to the want of forest control in those days Kauri had only a nominal value, and the actual area of Kauri forest may have been much greater. The finest forests of thirty-five years ago were in the Northern Wairoa and Hokianga districts. How far there were continuous forests in those days is difficult to learn. At present the Kauri is seen in the form of strips and clumps distributed in forests of other trees. Mr. T. F. Cheeseman, in his "Illustrations to the New Zealand Flora," and in a lecture delivered a few years ago at the Auckland Institute, gives the following description of the physiognomy of a Kauri forest:—

> From a considerable distance these clumps are at once recognized by the manner in which they stand far above the adjoining forest, by the peculiar ramification of the trees, and by the dark dusky-green colour of the foliage. But it is from the interior of the forest that the Kauri is seen to the best advantage, and the majestic size and noble proportions of the tree can be best appreciated. On all sides rise the huge columnar trunks, sometimes towering up for more than 80 ft. without a branch, and tapering but slightly from base to summit, smooth, grey, and glistening. At the base of the trunk is the huge mound of debris produced by the fall of the bark, which is regularly cast off in large flakes. It is from this peculiarity that the bole of the Kauri is so free from the climbers and epiphytes which commonly clothe the stems and lower branches of the larger trees of the New Zealand forest. From the top of the trunk spring the immensely thick branches, often given out almost from a single point. These, with the branchlets and foliage, form a high-vaulted roof to the forest, through which a varying amount of daylight filters through to the ground. Owing to the great height of the trunk, and the fact that the branches are usually confined to the upper portion, and owing to the further fact that large trees of other species seldom grow plentifully intermixed with the Kauris of a particular grove, the forest has an open appearance not usually seen in New Zealand woodlands. Under the vaulted roof of branches the eye can penetrate far and wide among the massive trunks, which have hence been compared to the pillars of some vast Gothic cathedral.

Discoverer of the Kauri Tree.

According to Mr. Cheeseman the ill-fated French Commander, Marion du Fresne, was the discoverer of the Kauri tree. Captain Cook had previously found Kauri resin, but did not penetrate far enough inland to discover the Kauri tree. The Kauri is not a coast-margin tree or one of waterside swampy ground. Du Fresne describes the Kauri as a

Cedar with the leaves of an Olive ("un Cèdre à feuilles d'Olivier"). He says, "I had Cedars of this variety cut down whose trunks were more than 100 ft. long from the ground to the lowest branches and 52 in. in diameter. The trees are very resinous; the resin is white and transparent, and gives out an agreeable smell like incense when burnt. It appeared to me that this Cedar is the commonest and highest tree of the country. Its wood is elastic, and I judge it very suitable for making ships' masts."

There is no existing forest where the Kauri could be described as the commonest tree, and few, if any, trees left with clean boles of 100 ft. Du Fresne established a shipyard on shore for the preparation of ships' spars. Eighty-seven years afterwards Dr. Thomson was able to find the remains of these masts, showing the durability of Kauri timber under conditions promoting decay.

MAORI RECORDS.

Mr. Cheeseman has searched the literature of Maori records and obtained nothing of importance regarding the Kauri tree, and this negative result is confirmed by Mr. Elsdon Best, the Maori-lore authority of the National Museum.

KAURI HABITAT.

Broadly speaking, Kauri grows over one-fourth the latitude occupied by New Zealand. "The geographical range of Kauri, says Mr. Cheeseman, "is very limited. Some scattered trees exist in the North Cape Peninsula, especially between Tapotopoto Bay and Spirits Bay, but it is not found in any quantity to the north of Ahipara and Mangonui. From these two localities southwards to the Manukau Harbour on the west coast and Tairua on the east is the proper home of the tree—the district which for a hundred years has supplied almost the whole of the Kauri timber used in the Dominion or exported therefrom. Its extreme southern limit on the east coast is near Maketu, in the Bay of Plenty; on the west, in the vicinity of Kawhia Harbour. In the valley of the Thames an extensive Kauri forest once existed at Waiorongomai, near Te Aroha, but it has long since been cut down. A few isolated trees, however, still exist on the ranges flanking the Thames Valley beyond Te Aroha, the Gordon Settlement being the southern limit. In the Waikato district scattered trees or small clumps were once not uncommon on the west side of the Waipa, near Ngaruawahia, stretching southwards almost as far as Whatawhata. The southern boundary of the Kauri can therefore be said to coincide with the 38th parallel of south latitude. As for its altitudinal range, it descends to sea-level in many localities, but is most abundant from 250 ft. to 1,000 ft. of elevation. It is not common above 1,500 ft., although it occurs up to 2,000 ft. on the Cape Colville Peninsula, and between Hokianga and the Northern Wairoa." (Lecture, Auckland Institute.)

In other words, Kauri occupies the big peninsula of the North Island with Auckland lying nearly at its centre, while Kauri is practically absent from the little sandy peninsula in the extreme north.

THE CLIMATE WHERE GROW THE BIGGEST KAURI TREES.

The Kauri seems to have attained its largest dimensions near the "mixed" forest zone at the higher altitudes. It appears that Kauri forms the densest stands of timber on the warm coast lands, about latitudes 35 and 36; but the individual largest specimens are in the colder and wetter forest at the higher elevations. The two historical big Kauri trees of New Zealand, with their special Maori names (p. 42), occurred in the Tutamoe Forest on the range parallel to the Waipoua highlands, in forest similar to the upper limits of the Kauri forest at Waipoua.

Upper Limit, Kauri Climate.—Says Kirk, "Kauri is a lowland tree, becoming rare at elevations exceeding 1,500 ft., although solitary specimens were observed on the slopes of Mount Wynyard at 2,500 ft. or perhaps higher." ("Forest Flora," p. 150.)

The "Manual of the New Zealand Flora" (Cheeseman) places the upper limit of Kauri at 2,000 ft. The highest group of good Kauri trees near Waipoua is at the Stonehenge Falls ("Waipoua Kauri Forest," p. 51). This is at an elevation of about 1,100 ft. above sea-level. 100 ft. to 200 ft. above this, at the Marlborough Settlement, the rainfall is estimated at well over 100 in. There are fairly sharp frosts in winter, sometimes for three days together. Snow is very rare. There has been one fall, with 4 in. of snow, in the last twenty years. There is, however, sleet in most winters. Thus here the elevation makes a winter climate similar to that of Wellington (lat. 41°) at sea-level. April, May, and June are the pleasantest months of the year, with bright days and comparatively not much rain. August, September, and October are described as the worst for rain.

The moisture conditions are similar to those on the west coast of the South Island, forming a climate where forestry should be the essential industry, and dairying and cattle its adjuncts on strips of good soil. At the lower levels it is warmer and drier. Here Kauri grows so well that ordinary farming is quite secondary, both in money returns and in employment, to the Kauri industry. (*Vide* "Balance-sheet of a Normal Kauri Forest," p. 95.)

After heat and moisture, sun-power is the important factor in vegetation; and here it must be noted that the Waipoua Forest is in latitude 35½°, the same as Cyprus and, practically, as Malta (in the Mediterranean). These are latitudes near the summer maximum of sun-power. I judge the mean temperature here at 60°, and the extreme yearly range within 15° F. I judge the rainfall at 80 in. near the coast and 120 in. on the higher ground at 1,600 ft. elevation.

These figures are near those of Auckland or the wet southern coast lands of South Africa. Waipoua, even near sea-level, seems cooler than Auckland, though it has eighty miles "northing" from Auckland. In distribution the rainfall at Waipoua differs little throughout the year; and though, relative to temperature, it is comparatively dry in summer, years dry enough for "a good burn" in bush-clearing occur only at intervals. Briefly, it is a very wet extra-tropical climate, with an all-the-year-round rainfall. Except for the absence of occasional hot dry winds —"berg winds"—it scarcely differs from the forest country in the extreme south of South Africa, or the lower mountain coast climate of New South Wales, eighty miles south of Sydney. It is just the absence of hot dry winds that makes the fire-protection of the forests such an easy matter compared to the same work in Australia or South Africa. In the wet Knysna forest country of South Africa it has been found, after some one hundred and fifty years of trial, that, except on alluvial flats, the timber crop is the most valuable the country can produce, both as regards money returns and employment, which, as will be seen later, averages one family (white) per 100 acres. In the wetter parts, resembling Waipoua in climate, all soluble plant-food except inside the forest is rapidly leached out of the soil by the heavy rains, so that excessive and costly manuring is required, either for field crops or a good growth of grass.

The southern limit of existing wild forest of Kauri is detailed in Mr. Cheeseman's monograph mentioned above and in the text-books. Approximately it is latitude 38°. Probably Kauri would thrive in cultivated forest along the warm coast lands as far south as both sides of Cook Strait—viz., the sea-coast climate of latitude 44°.

At Otaki, forty miles north of Wellington, is a planted tree looking as well as any I have seen in the north. It is twenty-eight years old, and is 30 ft. high, with a diameter of 8½ in. It has been bearing cones for several years. It is in a sheltered locality near the sea, warm even for this enervating coast land.

The tree in the Wellington Botanic Gardens bears cones.

There are actually planted trees of Kauri in Botanic Gardens as far south as Dunedin growing fairly, and said to be hardy, with a mean temperature scarcely above that of London, England. They look fairly well, but naturally have not the vigorous appearance of the Otaki or New Plymouth planted trees.

KAURI RATE OF GROWTH.

DIAMETER-GROWTH.

The Old Authorities.—Laslet, so well known for his classic on timbers used by the Admiralty in England, after his visit to New Zealand as far back as 1840–43, cited 13·4 rings per inch of radius as the average Kauri growth on four specimens he had—or, in other words, 1 in. of diameter-growth in 6·7 years, or 6 years and 8 months.

In 1867 Dr. Hochstetter, in his book of travels in New Zealand, wrote that Kauri rings averaged ten to twelve per inch of radius, but he did not bring home the point that this was nearly double the growth of European forest-trees.

In 1874 J. C. Firth, in an article on "Forest Culture" read before the Auckland Institute, remarks: "For instance, every foot in diameter of Kauri represents half a century." (Trans. N.Z. Inst., 1874.) He was not aware that this is double the average rate of normal timber-growth in the Pine forests of Europe.

In 1876 Captain Campbell-Walker, the Indian forest officer, remarked, "The Kauri is a fast-growing tree."

In the report of the Timber Commission of 1909, p. 585, the Hon. E. Mitchelson was asked: "The fact of the Kauri or other native trees growing 1 ft. in diameter in twenty-three years does not prove it is a fast-growing tree?—I say, for a hardwood that is very fast. *Q.* Is not your land very good?—No, not extra good; it is semi-volcanic."

Mr. Mitchelson reported the following growth of native trees he had planted himself on his ground at Remuera, and invited the Commissioners to come and see the trees for themselves. At twenty-three years of age the following diameters: Kauri, 10 in.; Totara, 13 in.; Rimu, 8 in.; Puriri, 9 in. I remeasured these trees in 1916 and found the growth well maintained.

It is curious that these authoritative statements should have been disregarded for so long, especially that from the Indian forester, coming as it did from one used to the growth of quick-growing tropical trees. Popular beliefs are proverbially hard to kill, but one would have thought that a line of inquiry so gravely affecting the policy of the country would have been taken up by the scientific societies.

Cheeseman's Discovery.—The distinguished Curator of the Museum at Auckland, Mr. T. F. Cheeseman, took the first step in scientific forestry in New Zealand when he showed (Trans. N.Z. Inst., 1913) that the popular notion with regard to the slow growth of Kauri was wide of the truth. Kirk, indeed, twenty-five years previously, had quoted similar figures, but only in a general way and without understanding their significance.

Mr. Cheeseman records his discovery in these words:—

> My own doubts as to the accuracy of the common belief date back as far as 1884, when I counted the rings of growth in a Kauri tree 4 ft. in diameter cut down at Whangarei. To my surprise I found that the tree had only 188 rings, or 7·8 per inch of radius. A few years later I examined another tree at Coromandel, with a diameter of 5 ft. 6 in., which proved to have 280 rings, an average of 8·5 per inch. Other trees were counted from time to time; but during the last two years I have been able to obtain quite a number of accurate measurements, amply sufficient, I think, to form the foundation of some general conclusions. . . . The examination of twenty-nine sections [of Kauri trunks] gives 9·7 as the mean number of annual rings for each inch of radius; or, in other words, *an average Kauri tree grows an inch in diameter every four and three-quarter years.*

Cheeseman's seven smaller trees, of economic size, gave an average of 8·2 rings per inch of radius. A brief review of Cheeseman's valuable paper is given in Bibliography, Part II.

The Lands Department Forestry Report for 1904–05 records that the late Mr. Matthews, Chief Forester, had found regrowth Kauri up to 1 ft. in diameter which could not be older than twenty-five or thirty years. This was in Cascade Creek, Waitakerei Ranges, near Auckland City. The Kauri had come up thick after a forest fire.

As one rides into the Waimamaku Village (a dairying area cut off from the Waipoua Forest) one sees a fence of split Kauri palings round the schoolhouse. The wood of the palings is weathered and shows the yearly growth-rings very clearly. On one paling are rings, $\frac{1}{4}$ in. broad; on another, $\frac{1}{8}$ in.; on a door-lintel I saw rings $\frac{1}{5}$ in. broad. I counted the rings on a number of stumps at Waipoua and Puhipuhi, and these (excluding dominated heart, which was often present) averaged about eight rings per inch of radius in the economic part of the trunk—viz., up to $1\frac{1}{2}$ ft. or 2 ft. of radius.

My general observations of the growth of Kauri, which will be published shortly, do not materially alter Mr. Cheeseman's figures. (See also p. 158.)

KAURI GROWTH-RINGS, TROUNSON PARK.

In 1916, on the way back from doing the Waipoua Forest demarcation, passing Trounson Park I noticed on the outside a number of sawn sections of stump and crown, where Kauri logs had been removed. I immediately resolved to spend the day there and investigate the rings. They had been weathered and thus rendered clearer. As there were a large number of sections to count from, I confined my investigations to those with quite clear rings.

Dominated Heart.—Most of the sections showed a small core of very fine rings in the centre, some twenty-five or thirty to the inch, marking the period during which the seedling or sapling tree had been struggling through the dense covert of the under-forest. This "dominated heart," in every case, was absent from the crown sections. The size of the trees counted varied from 3 ft. in diameter to 13 ft.

The average of the rings of growth, excluding dominated heart as above, worked out to 7·88 rings per inch of radius, the size of the trees and thickness of the rings being as follows:—

Number of Tree.	Diameter of Section. Ft.	in.	Number of Rings per 1 in. of Radius.
1	6	0	8
2	5	0	7
3	5	0	9
4	3	0	6
5	5	6	6
6	13	0	8
7	12	6	7
8	7	0	6
9	5	4	8
10	6	0	8
11	6	0	12
12	14	0	7
13	13	0	10
14	12	0	7
15	6	6	7
16	5	0	8
17	4	0	10
			134

Average, 7·88

The rings were computed by laying a mathematical scale over a radius of average length. The computation was not carried beyond 3 ft. diameter, which is about the diameter limit of a log of economic size.

This result, **7·88** rings, may be compared with Cheeseman's figure as above for seven trees not above economic size—viz., **8·2** rings.

Diameter-growth of European and South African Trees.

If we take the five standard trees of central Europe, in medium-quality forest, the average growth is 10·8 in. diameter at age 100 years, according to the standard tables published in Sir William Schlich's "Manual of Forestry." (See table, p. 14.)

If at 100 years of age the average diameter is 10·8 in. or radius 5·4 in., during 1 year the radial growth is 0·054 in. Dividing 1 by 0·054 we get 18·52: viz., it requires on an average 18·52 years to produce an inch of radial growth in European forests. Then comparing Schlich's and Cheeseman's data one has 18·52 (Schlich) ÷ 9·7 (Cheeseman) = 1·91: viz., Kauri average diameter-growth is nearly twice European forest trees diameter-growth. The slowest-growing European timber-tree at 100 years is Beech with 22 average rings; Oak has 16 rings. The shade-bearing Silver-fir, which in its mode of growth most resembles New Zealand native trees, has 16·94 rings per inch of radius, or an inch of diameter-growth in 8½ years. It has thus exactly half the growth in thickness of Kauri if we take Cheeseman's Kauri trunks of economic sizes only.

Coming south in Europe to the latitude and temperatures of the Waipoua Forest, Cluster-pine, the chief forest-tree of Portugal, *shows a normal of 14·4 rings* per inch of radius. Cluster-pine grows so quickly in Portugal and France that it will pay, on poor soil, to plant it and grow pit-props for England. This is one of the biggest forest industries in the world, England paying £3,500,000 yearly for these pit-props. This figure is equal to the value of the whole export to England from the neglected wild forests of Canada; while, curiously, the same figure represents the penalty Australia is paying yearly for its backward forestry.

Thus we see that Mr. Cheeseman's figure gives Kauri nearly double the growth in thickness of the average forest-trees of south England and central Europe, and a diameter-growth 41 per cent. more rapid than the great pit-timber tree of south Europe (*Pinus pinaster*).

The Podocarpus timbers of South Africa (three species) seem to grow at much the same rate as the Podocarpus timbers of New Zealand—Totara, White-pine, Black-pine, and Miro.

Average figures for Stinkwood (*Ocotea bullata*) and White-pear (*Apodytes dimidiata*), two important hardwoods in the forest of South Africa, like the mixed forest of New Zealand, are 15 rings per 1 in., or 1 ft. diameter in ninety years. Curiously, I obtained the same average growth-figure from measurements taken at random on forty logs as they came to the Government sawmill in the largest pine-forest of Cypress. These logs were Aleppo-pine, which forms nearly all the timber forest of Cypress. ("Cypress Forestry," p. 49.) This 15 rings per inch may be compared with Cheeseman's 9·7.

HEIGHT-GROWTH OF KAURI.

Here one cannot do much with counting the rings, though it would be possible to get some suggestive and possibly useful figures by taking the difference in the numbers of rings on basal and crown sections. At this moment there is a lot of useful material for such a study in an old Kauri-working outside Trounson's Park near Kaihu. I spent one day there counting rings, but I had other engagements preventing a further stay. There must be the same opportunity in many other old Kauri workings where the trunk has been rolled away and the crown section left in place opposite the stump section. The difference between the number of rings on each section is the age up to the time when the tree reached the height of the top section above the ground, which height can be measured now on the ground, provided, of course, that the crown showing the top section has not been moved. Ordinarily it lies where it fell. No one wants to move it.

It is unfortunate that as yet the height-growth generally of New Zealand timber-trees in their forest surroundings can only be judged: there have been no foresters to measure them in New Zealand. As far as I have been able to judge the height-growth of the native forest-trees, they are decidedly faster than European forest-trees; while Kauri averages somewhat faster than Cluster-pine in Portugal, which, as seen, grows fast enough for Portuguese farmers to plant at a profit for mining-timber to send to England. I gave various figures of Kauri growth in my Forest League address printed in the *Journal of Agriculture* for October and November, 1916. It will be enough to note here that Kauri, in a collection of native planted trees, is usually one of the fastest growers, and usually has the best shape. The conditions must be altogether different from those of its native forest for Kauri to grow at a rate slower than 1 ft. in height per year. In the table (p. 15) Kauri has the most rapid height-growth of all the native trees. The two photos opposite show the height-growth of planted trees at Auckland.

The young Kauri tree in the house-grounds of the Hon. E. Mitchelson, Remuera, Auckland, at seven years of age is 14 ft. high. (See photo.) The tiers of branches show clearly the length of the yearly shoots—2 ft. The soil is an ordinary clay. This is between two and three times the growth of an average European timber-tree of the same age.

At Mr. Mitchelson's former residence (now a convent), Auckland, I saw a young Kauri which at thirty-three years of age is 12 in. diameter and 45 ft. high.

At page 138 Short-leaf pine is described as one of the trees suitable for introduction to the Kauri forests. It is the most widespread of all the pines of North America, and is being extensively studied and cultivated by the Forest service. The typical tree aimed at has the same age as what I have taken for the Kauri tree of the future—viz., 100 years. But, comparing the two type trees, the American pine, put alongside Kauri, has—

Diameter, three-quarters of Kauri.
Height, three-quarters of Kauri.
Cubic content Short-leaf pine, 270 board feet.
Cubic content Kauri, 900 to 1,000 board feet.

Mr. G. A. Green, the well-known horticulturist, describes watching two Kauri saplings continuously for forty years, with the result that at fifty years* of age they were about 50 ft. high *and about 2 ft. in diameter.* (*Farmer's Advocate*, 5th April, 1919.) They were growing on the edge of a piece of native "bush" under quite natural conditions.

COMPARATIVE GROWTH, EUROPEAN AND NATIVE TREES.

Let us glance now at what is the yearly average height-growth of European forest-trees. For this purpose we may again take Schlich's tables. Spiedel's yield curves are given as a frontispiece to my "Journal of a Forest Tour." They differ just as much from Schlich's figures, as one would expect considering that they are of more local application—south Germany. Thus, for Scotch-pine at 100 years: Schlich, 72 ft.; Spiedel, 75 ft. For Spruce at 60 years: Schlich, 52 ft., Spiedel, 52 ft. For Silver-fir at 80 years: Schlich, 65 ft.; Spiedel, 62 ft.

Schlich's general-average height-growth figures for the five chief European forest-trees—Oak, Beech, Scotch-pine, Spruce, and Silver-fir—are as follows:—

	Diameter.	Height.
At 10 years the average is ...	0·6 in.	6 ft.
,, 20 ,, ...	1·3 in.	13 ft.
,, 25 ,, ...	1·9 in.	18 ft.
,, 30 ,, ...	2·4 in.	23 ft.
,, 40 ,, ...	3·6 in.	33 ft.
,, 60 ,, ...	6·1 in.	52 ft.
,, 80 ,, ...	8·5 in.	67 ft.
,, 100 ,, ...	10·8 in.	78 ft.
,, 140 ,, ...	14·1 in.	96 ft.

It will thus be seen that at all ages the mid-European forest-trees show a growth decidedly below an average of 1 ft. per year in height—in fact,

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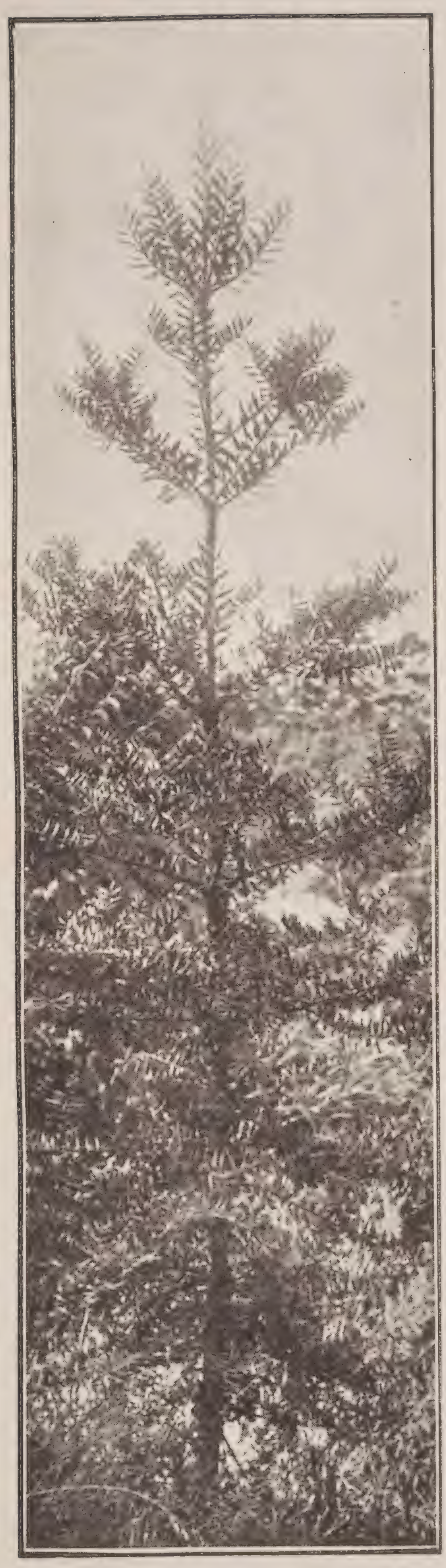
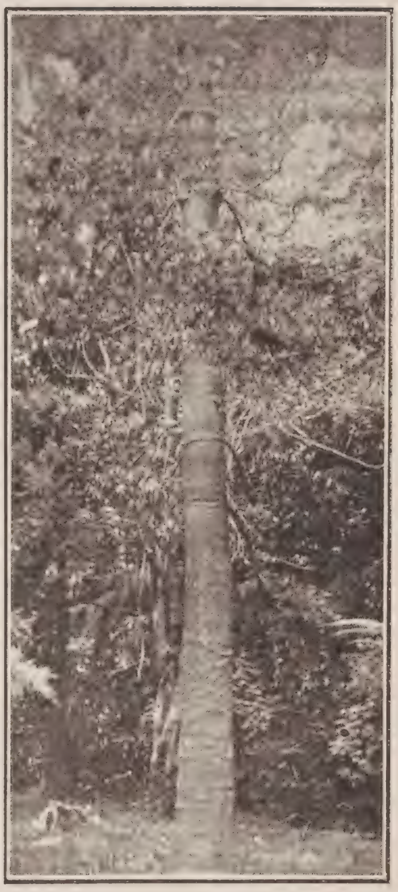
* Double the average diameter-growth assumed at p. 73.



A KAURI TREE GROWING 2 FT. A YEAR.

Remuera, Auckland; planted by Hon. E. Mitchelson; 14 ft. high at seven years of age



One of the well-known young Kauri trees in the Auckland Domain, planted in 1865 (*Trans. N.Z. Inst.*, p. 374), and thus now fifty-one years old. It measures 16 in. diameter at 5 ft. above the ground and is 52 ft. high. The handkerchief spread at the base is 18 in. Trees of this size are now actually being milled in some places.

Photo, D. E. Hutchins.]

[*To face p. 14.*

growth averages only a little over three-quarters of a foot per year; and, further, to produce a 1-ft.-diameter tree an average of 111 years is required.

It will be seen also that young European trees at 25 years of age, grown in dense forest, have an average diameter of only 1·9 in.; or, expressed in another way, to make 1 in. of diameter-growth 13·2 years are required; while their average height-growth up to 25 years of age is only 18 ft. ÷ 25 years = 0·72 ft.

Cluster-pine in the State forest of Leirìa, Portugal, where its growth is seen at its best, has the following average height-growth:—

At 10 years	16 ft.
,, 30 ,,	46 ft.
,, 50 ,,	62 ft.
,, 80 ,,	79 ft.

It is open to any one to abstract the standard European forest figures, as I have done here for ready reference, and to compare them with Kauri grown under forest conditions, either as a planted tree or a regrowth tree in the bush. The following then becomes apparent:—

Summary of Kauri Growth.—Kauri grows in thickness nearly twice as fast as the five chief European forest-trees, and in height-growth 2·3 times as fast, taking the figures on Mr. Matthews's table below. It grows about as fast as the quick-growing Cluster-pine of southern Europe.

New Zealand Young Trees.—The table below is condensed and rearranged from that at page 78 of Mr. H. J. Matthews's book, "Tree-culture in New Zealand." A list is there given showing the rate of growth of Kauri and the chief timbers growing with it, in the case of trees planted by Mr. Hall, of Parawai, Thames. The list purports to show the slow growth of the native trees. It does the reverse, if we compare these figures with the rates of growth of European forest-trees, or, indeed, with the forest-trees of other countries, as I shall show more fully later. Enough has been said here to show that Kauri amongst forest-trees is a fast grower.

Mr. Matthews attempted to explain these figures by stating that Kauri and other native trees grow quickly when young. That was not the opinion I heard in Auckland; indeed, Mr. Cheeseman and others consider a slow growth at first as characteristic of the Kauri tree. In my "rings-of-growth" observations the "dominated heart," indicating slow early growth, is a common feature.

MR. MATTHEWS ON GROWTH OF NATIVE TREES.

	Years old.	Rings or Years per Inch of Radius.	Years per Inch of Diameter.	Height-growth per Year, in Feet.
Kauri	23½	6·26	3·13	1·49
Rimu	27	7·72	3·86	1·11
Totara	28	5·60	2·80	1·48
White-pine	25	8·34	4·17	1·40
Puriri	26½	3·70	1·85	1·41
Tanekaha	24	6·86	3·43	1·29
Means	26	6·42	3·21	1·36

Against mid-European timber-trees averaging (see table, p. 14), at 25 years, 13·2 years per inch of diameter-growth and 0·72 of a foot height-growth per year. Then taking the figures from each table :—

$\frac{13{\cdot}2 \text{ Schlich}}{3{\cdot}2 \text{ Matthews}} = 4{\cdot}1$; or Schlich takes over quadruple the time of Matthews to obtain 1 in. of diameter-growth.

$\frac{1{\cdot}36 \text{ Matthews}}{0{\cdot}72 \text{ Schlich}} = 1{\cdot}9$; or Matthews nearly double Schlich's height-growth in a year.

Summary of Growth of Chief Native Timbers.—Up to twenty-five years of age the six most important New Zealand timbers, as grown at Mr. Hall's, averaged $1\frac{1}{3}$ ft. in height-growth per year, Rimu being the slowest. They took rather over three years to grow 1 in. in diameter, White-pine being the slowest and Puriri the fastest. This is growth partially in the open, compared with growth in European forest. The comparison quoted above for Kauri diameter-growth is more reliable since that relates to forest-growth in both cases. Thus, compared to the five chief European timbers growing under normal conditions in their forest, the chief New Zealand trees here show the same thickness in less than a quarter of the time, and the same height in practically half the time.

I have tried to get particulars of the growth of Mr. Hall's trees to date, but he is no longer living, and the identification of the trees is now doubtful.

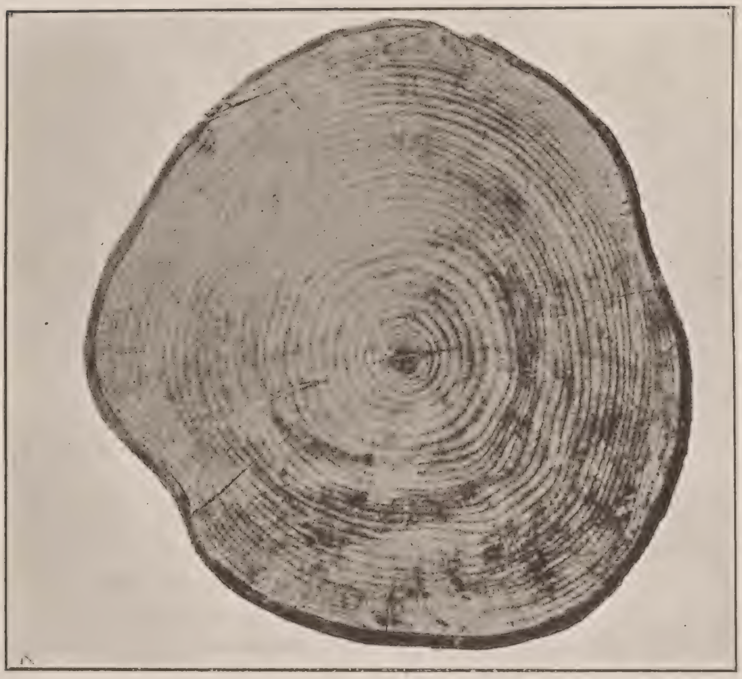
These figures may be memorized (and it is worth remembering what Schlich and Matthews have to say on this vexed question) in the following lines :—

Taking Schlich for Europe, and Matthews for home trees;
Its near twice home height and thickness quadruple
That in young trees one sees.

The following particulars of growth of native trees are reproduced from my inaugural address at the opening meeting of the New Zealand Forest League. It was reprinted, but is now out of print :—

"In the New Plymouth Botanic Gardens (Pukekura Park) is a good collection of the native timber-trees of New Zealand. These have been planted, and their exact age is now known. The shade and moisture conditions are much like those in the native forest. These planted native trees are growing at an average rate of 2 ft. or 3 ft. per year in height, while some of them are growing faster. Thus a graceful Birch-like Ribbonwood tree (*Plagianthus betulinus*) in front of the tea-house is 25 ft. high at six years of age. A prominent New Zealand Mahogany tree (*Dysoxylon spectabile*) has grown 4 ft. during the past summer. I saw a score or more young Rimu trees growing at the rate of 2 ft. or 3 ft. per year, and one thirty-year-old tree making shoots of 3 ft. per year. The imported trees, apart from Insignis-pine and one or two Eucalypts and Wattles, grow no faster, says the Curator, an experienced and reliable man. I saw an English Oak and a Puriri of the same age growing side by side, the Puriri decidedly the larger tree. Two Puriri trees, seven years of age, average 18 ft. high. I saw a perfectly grown little Kauri 18 ft. high at twelve years of age. Elsewhere in New Plymouth is a healthy Kauri tree which at thirty years of age is 9 in. in diameter and 38 ft. high; and there, of course, Kauri is too far south for its best growth. Nevertheless, according to the standard-yield tables, an average Scotch-pine in central Europe forests is only 3 in. to 4 in. diameter and 29 ft. high at the same age. Thus here, in

PLATE III.



RIMU

Auckland Domain. 42 years old, showing 42 rings; diameter, 15 in.
(When thinned for park purposes the growth deteriorates.)

Photo, Trans. N.Z. Inst., Vol. 38—Stewart.]

[*To face p. 17.*

a climate too cold for it, is Kauri growing faster than the ordinary Pine tree of Europe.

"At Dargaville (latitude 36°) Mr. Mitchelson showed me a Kauri he had planted that at sixteen years from planting was 9 in. in diameter and 32 ft. high. Here is a Kauri, in its own climate, with nearly double the growth of the New Plymouth tree, and far beyond all practical comparison with Scotch-pine, for the normal for Scotch-pine at sixteen years in medium-quality forest is 1½ in. diameter and 13 ft. in height.

"In the Jubilee Park, Dunedin, are two Beeches growing side by side —*Fagus fusca* (New Zealand) and *Fagus sylvatica* (Europe). They are the same age, but the New Zealand Beech is distinctly larger. In the same park is a collection of European and New Zealand Beech trees which show similar result.

"*Auckland Domain.*—A number of planted native trees in the Auckland Domain were systematically measured, and described in a paper read before the Auckland Institute in 1887. They were then twenty years old from planting, and this investigation showed that at that age the native trees averaged about 1 ft. in height-growth per year, and about ⅛ in. diameter-growth per year. There the conditions are not so favourable as in the New Plymouth Botanic Gardens; the surroundings are less like the shade and shelter of the native forest, but the growth is still far above the European forest standard. Rimu and Kauri, the two important timber-trees of New Zealand, grew the fastest, and at twenty years they averaged 8 in. diameter and 28 ft. high. The rapid early growth is well shown in this photo of yearly growth-rings (Plate III). A Scotch-pine on soil of medium quality in central Europe at the same age will average 2 in. in diameter and 17 ft. in height (Schlich's 'Manual of Forestry,' vol. 3, p. 343). Thus the standard European pine has little more than half the height-growth and exactly one-fourth the thickness of these Rimu and Kauri trees in the Auckland Domain at the same age."

In December, 1916, I remeasured the trees in the Auckland Domain, they being then fifty years old. Diameters were taken at 5 ft. above the ground to the nearest inch: the heights were taken with Stanley's apomecometer, the instrument used by H. J. Elwes, F.R.S., in the measurements taken for his work in "Trees of Great Britain and Ireland." My instrument was verified by Messrs. Littlejohn, of Wellington, and an index correction applied. It will be noted that the growth of these trees has fallen off since they were opened out to produce park conditions. The boles of the trees have clearly suffered from more than one overthinning, some branching badly and some forking; indeed, most of the trees, excepting Kauri and White-pine, have boles too branchy to measure. The boles also show distortion from bark-injuries, the locality "Lover's Walk" being a favourite public resort. Tanekaha, of which there are ten trees, is particularly badly forked and suffering from bark-injuries. This, in the forestry of the future, will probably be the second or third most valuable native tree in the north. The present appearance of these native trees in the Auckland Domain is not up to the average of planted native trees elsewhere. Thus in the "Promenade," Palmerston North, I saw a Celery-top that at four years planted was 11 ft. high. A minute's glance round this interesting collection of native trees shows that the best timber-producers are Totara and Kauri. There are half a dozen Kauri rickers showing good clean growth, and averaging over 1 ft. diameter and 50 ft. high.

Near the native trees are some fine specimens of introduced trees—Cypresses, a Tulip tree, and many Oaks. A Deodar, the best timber-tree in the Auckland Domain, is some 20 in. in diameter and shows 50 ft. of good straight bole. Near it is a gigantic Macrocarpa Cypress, 5 ft. in diameter, and looking about 100 ft. high; but, alas! nearly all branches. These trees are probably older than the native trees, but I was unable to secure data. The growth, however, is so far beyond that of the native trees that the lesson here given to the forester seems to stand out clearly: *Conserve the native trees, for they grow about twice as fast as European forest-trees; but if one has to go to the expense of planting, use introduced trees, and take the risk of disease or other failure.*

NATIVE TREES, AUCKLAND DOMAIN: FIFTY YEARS PLANTED.

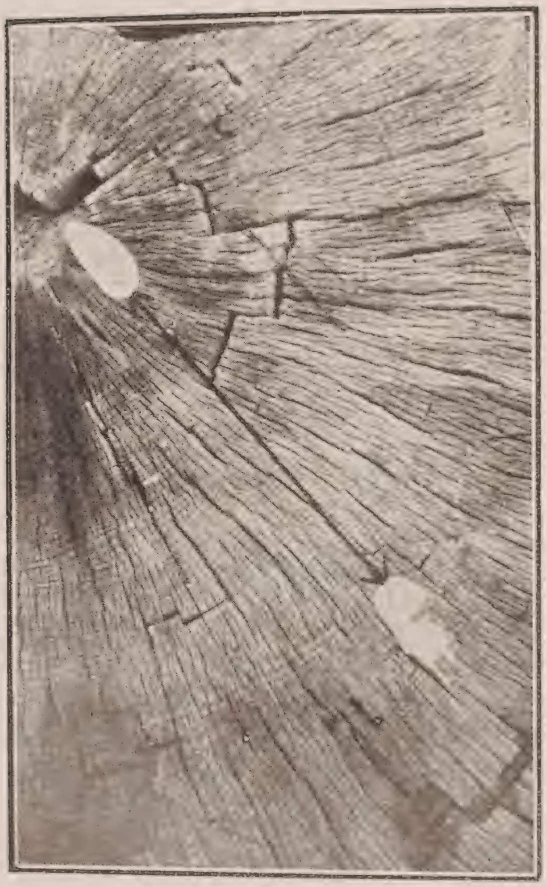
	Trees.		Diameter.		Total Height.
Kauri	10	averaging	15 in.	by	49 ft.
Totara	6	,,	16 in.	by	40 ft.
Rimu	17	,,	13 in.	by	44 ft.
White-pine	2	,,	15 in.	by	54 ft.
Celery-top (Tanekaha) ...	10	,,	10 in.	by	37 ft.
Miro	6	,,	11 in.	by	39 ft.
Honeysuckle (Rewa) ...	1		11 in.	by	42 ft.
Karaka	1		7 in.	by	45 ft.
Pohutukawa	...		(bushy)		57 ft.

KAURI TENDS TO GROW SLOWLY WHEN YOUNG.

The Kauri rings on the old cut trees outside Mr. Trounson's Kauri Park mentioned above confirm Mr. Cheeseman's observation (Trans. N.Z. Inst., June, 1914, p. 16) that Kauri rings show little of that decrease in size near the bark, which is the case with most other trees. The rings I examined showed clearly that the slow-growing period of these Kauris had been in their youth, when, as light-demanding trees, they had had to fight for their existence with the dense underwood. Once above the under-forest Kauri grows away, and it continues its rapid growth when, as a member of a sparse over-forest, its great arms are flung abroad to drink in the powerful sunlight of these latitudes, while its base is nourished and shielded from sun and wind by the dense underwood; nourished, too—we know not how much—by Mycorhizas and by root-parasitism. There is a hidden forest world below the surface, which so far does not appear to have been much studied in New Zealand. I see no references to it in the "Transactions of the New Zealand Institute" since Hooker, many years ago, recorded root-nodules on White-pine; but there are indications that fungus and bacterial organisms play a part in the growth of the New Zealand forest.

Kauri and Gum Tree growing the same at Age 50.—At St. Leonards, Culverden, a cut stump of *viminalis* Gum, 35 in. diameter and fifty years old, shows rings near the bark about the same as Kauri at the same age—viz., ⅛ in. broad. At the centre the rings are ¾ in. broad. There is an object-lesson on this stump. It shows the real difference in growth between Kauri and one of quite the quickest-growing of the Gums in New Zealand. The difference is in the first fifty years of growth. The Gum had grown under normal conditions.

PLATE IV.



Rings of growth on a 4-ft.-diameter Kauri tree at Waipoua. The white mussel-shells show the economic part of the radius, with a growth exactly four times the average of European forest-trees.

Photo. D. E. Hutchins.] [*To face p. 19.*

PHOTO OF KAURI RINGS.

Plate IV shows a 4-ft.-1-in.-diameter Kauri tree as cross-cut, with the yearly rings weathered and quite clear. They show a diameter-growth almost exactly four times the average of European timber-trees.

	Years.
Average, as above, five chief European timbers, per foot of diameter	111
Average this Kauri (as below) per foot of diameter ...	28

In this tree the "dominated heart" shows rings averaging only $\frac{1}{30}$ in. broad. In the photo the dominated heart extends to the mussel-shell.

When taking this photo I stuck on two mussel-shells to show what may be termed the business part of the diameter-growth. After 2 ft. or 2½ ft. of diameter the stem of a Kauri tree in a cultivated forest represents too high a capital value to leave uncut. Thus the part of the radius between the two mussel-shells on this photo indicates the part which can be grown economically. On this stem the dominated heart is represented by 3 in. of radius. The economically valuable part of the radius is shown by the arrow on this photo, 1½ ft. long. Here I counted 84 rings, or 56 per foot of radius, or 28 per foot of diameter, along a radial length of 1½ ft., which means that the economical growth here was 1 ft. of diameter increase in twenty-eight years—an unusually fast growth. A few of the rings are as broad as ¼ in. I have seen ½ in. rings on Kauri, and Mr. Cheeseman records rings up to 1 in. (Trans. N.Z. Inst., June, 1914, p. 18.)

Favourable as is the growth of Kauri compared to other timber-trees in both thickness and height, there is another important point in the timber-growth of a tree—a third dimension! Here Kauri surpasses most trees and all giant trees with which it might be compared. The taper or form-factor of Kauri is discussed at page 48.

While these pages were in the press Mr. Lane-Poole, the Conservator of Forests, Western Australia, wrote thus to the Lands Department, New Zealand, regarding certain specimens of New Zealand wood that had been sent to him by the Lands Department, Wellington: "This sample (Kauri) has a mean diameter-growth per year of no less than 0·28 in. . . . This result is very much at variance with the accepted theory, which I think had birth in New Zealand, that Kauri is too slow-growing a timber to repay the cost of treating on a scientific forestry system."

MNEMONIC.

In old trees the growth-rings show clearly
That the five chief timbers of Europe
Have but half the stem-thickness of Kauri,
Nor in height do they come near our Maori!

KAURI TIMBER.

VALUE OF KAURI TIMBER.

Just because it was so abundant in the old days and New-Zealanders took no care of it, Kauri was used for various menial purposes—for butter-boxes and packing-cases in Australia, and in New Zealand as an ordinary house-building timber.

Laslet's classic, on timbers used by the British Admiralty (2nd edition, p. 390), says, "It is exceedingly doubtful if any pine tree in any part of the world is capable of such wide application, possesses so many good qualities, and *is so relatively free from defects.*"

As mentioned in my inaugural address to the Forest League, pre-war prices of Kauri on the English market were 4s. per cubic foot for Kauri, against 3s. for such valuable timbers as Black-walnut and Pencil-cedar, 1s. 8d. to 5s. for Mahogany, 3s. for quartered Oak—in fact, there is no ordinary good timber that fetches a higher price on the English market than Kauri. Kauri is equally in favour on the Australian market. "Kauri possesses a larger number of good qualities than any other pine known to commerce," says Kirk in the best chapter of his "Forest Flora" (p. 143). Said Professor Scott, speaking recently at the University Senate, "No timber in the world approached Kauri in its suitability for ship-building. He knew of many instances in which vessels built of Kauri timber remained absolutely sound after forty years. In the Clyde every yacht-designer specified that the deck-timber should be Kauri, but it could not be obtained . . . owing to our destruction of the forests."

Kauri and Oregon.—In northern New Zealand Kauri is preferred to imported Oregon timber (Douglas). It is mentioned that when at Whangarei boats were made of Kauri and of Oregon the Kauri boat had a higher value, sometimes almost double that of the Oregon boat.

Said the Timber Commission of 1909 after their exhaustive inquiry, "Kauri is our finest timber, combining strength with durability, and being easy to work." After enumerating the various purposes for which Kauri is employed, they added, "It is used for almost any purpose needed in the building or timber trades." Outside New Zealand its great use in Australia is for furniture. One sees Kauri furniture everywhere in Australia; it works so easily, and does not warp or crack under the trying Australian climate. Kauri has been aptly called the Teak of Australasia: it is, in fact, put to the same multiplicity of uses in Australasia as is Teak in India. Kauri is not quite so strong nor so durable as Teak, but it is strong enough and durable enough for all ordinary purposes; and, happily, it is not so heavy as Teak. Teak, air-dry, averages 40 lb. per cubic foot (Gamble); Kauri, 34 lb. (Laslet). Kauri is stronger than all the ordinary pines and softwoods, and not much heavier. It is not so strong as Pitch-pine, but lasts longer in the ground. Its weak point is its shrinking, and some tendency to warping when first cut. These defects are perhaps due to cutting out of season, and more certainly to putting ill-seasoned boards and scantling into joinery. Both are remediable. Cutting out of season would be remedied straight away as soon as systematic forestry was introduced to New Zealand (p. 80).

Kauri timber working thirty years ago is described and illustrated in Kirk's "Forest Flora." The endless procession of logs being rolled out and the water-carriage are well shown.

RECOGNITION—FOUR CLASSES.

Kauri timber is easily recognizable; it cuts like cheese under a sharp knife, and generally shows a peculiarly speckled surface on all sections tangential to the axis of the bole.

Mr. E. Bartley, architect, in a paper read before the Auckland Institute in 1885, distinguished four classes of Kauri—viz., red, white, black, and a soft kind from Tairua.* Abstracts from his paper have been quoted since. I think the original worth reproducing:—

> (1.) *Red* is the best general building-timber, close-grained and very durable for Kauri, but rather gummy, and shrinking and warping badly. A 40 ft. beam has been known to shrink 1½ in. in length, and a weatherboard ¾ in. in 20 ft.; so that Red Kauri should be used for beams or framing, but not for joiners' work.
>
> (2.) *White* is tough, stronger than Red but not so durable; a good timber for joiners' work, since the endways shrinking is almost nil, and it does not warp after a fair amount of seasoning. Largely used by boat-builders on account of its bending well.
>
> (3.) *Black* comes from the west coast. It is only fit for rough work, is heavy with gum, and the most durable of Kauri timbers. It is thought that for fencing it lasts as long as Puriri.
>
> (4.) The soft kind from Tairua is *the* timber for joiners' work and mouldings. It is reputed to be quite free from shrinking and warping. . . . If this and White Kauri only were used for joiners' work we should seldom hear of ruined ceilings or twisted doors and sashes. This kind of Kauri is only found in the Tairua district.

In the subsequent discussion of the four classes of Kauri a doubt was expressed whether these classes depended on location or age. (Trans. N.Z. Inst., 1885.) Kirk in his "Forest Flora" (p. 146) discusses this point. There seems little reason to question Kirk's opinion that, as with New Zealand Mahogany (Kohekohe) and some other trees, there are degrees of lignification, or heartwood formation, in Kauri timber, and that (2) and probably (4) of Bartley's classification represent young partially lignified heartwood. Then follows the important point that the "Kauri tree of the future" in the cultivated forest, *a tree of 2 ft. diameter or a little more, will represent just the most valuable sort of Kauri timber* for joinery and furniture, the common purpose for which Kauri timber is wanted.

Campbell-Walker cites a case of young immature Kauri lasting as sleepers better than Totara.

KAURI SAPWOOD AND HEARTWOOD.

As Good for Export.—It has been stated that Kauri sapwood was as good as heartwood indoors. That is correct in countries where wood-borers do not abound, and, as the White-pine borer does not survive in Australia, which is the chief outside market for Kauri (and furniture is the great use for Kauri there), the statement that Kauri sapwood is as good as Kauri heart has much truth in it. (See also p. 73.)

As Good for New Zealand, with Better Building.—And the statement may be true for New Zealand when builders decide on spending £15 or £20 extra on treating with a zinc salt all sawn and planed timber before it goes into a house. It has been estimated that tank or brush treatment with an antiseptic would not run to more than this for a six-roomed wooden house. It would get rid of borer, with its danger to furniture, and it might prolong the average life of a wooden house from thirty or forty years to the indefinite time it has in other countries; while after a time the borer might disappear, as have some other house-pests with better-kept houses!

How Good at Present.—The Hon. E. Mitchelson, who has had the experience of a lifetime in the practical use of Kauri timber, has given me his opinion that if Kauri timber is brought in and sawn up quickly, before the borer can get into it, the difference between Kauri heart and Kauri sap is not much for ordinary building purposes. If sapwood quite free from borer is put into a new building it will have an average life of twenty-five years, which is as much as most softwoods. On the other hand, Kauri heartwood indoors is practically everlasting.

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* The Tairua River tapped the Kauri in the heart of the Coromandel Peninsula, where the bulk of the area required for the future Kauri industry of New Zealand is to be found (p. 4).

Out-of-doors.—Out-of-doors Kauri sapwood rots as quickly as ordinary white deal, while the heartwood of trees in the forest remains sound for an indefinite time. I have a photo of a Kauri tree standing upright in the Waipoua Forest, with the sapwood shed and lying in a heap of fragments at the base. The stem of heartwood, as it stands, suggests a peeled cucumber!

Put to various uses out-of-doors Campbell-Walker averages Kauri heartwood as lasting about twenty years. He gives it double the life of Tasmanian Blue-gum.

Prices.—The present prices of Kauri (1916; there has been a further large rise since) in Auckland are as follows:—

	Per 100 sup. ft. s.	d.
First class—clean heartwood	26	6
Medium—clean sapwood without any pinholes ...	21	6
Third class—with worm-holes through it... ...	12	6

It will thus be seen that there is no great difference in the actual market value of sound heart and sound sapwood of Kauri, provided it is free from borer.

What is known as rough-heart Kauri is resinous and very durable, but there is only about 10 per cent. of this in a tree.

The average cost of getting 100 sup. ft. of Kauri to market, with much expensive working, was quoted eight years ago by the Kauri Timber Company as 12s. 5d. (Timber Commission Report, p. 565); so that, adding the secretary's estimate of profit to the company (1s. 7d. per 100 ft.), all above 14s. represents the market royalty value of the Kauri timber—say, about 8s. 4d. This figure, it will be remembered, is for working in roadless undeveloped forest, where the cost of extraction is about three times what it would be with the forest in order. Now, 8s. 4d. per 100 sup. ft. (= 1s. per c. ft.) is the figure that I have taken in these pages as representing nearly the present-day market royalty value of Kauri.

KAURI AS A FANCY WOOD.

One of the chief uses for Kauri has been as a furniture timber. This may be its only use for the next century, till the new supplies produced by better forestry come forward. For furniture the figured and fancy-marked wood of Kauri is particularly important. Mottled Kauri is discussed by James Stewart, C.E., in a paper read before the Auckland Institute. He says that it has been ascribed to a timber-disease and to a different variety of the Kauri, but examination shows that it is a peculiarity due to an abnormal growth of bark-tissue within the sapwood. The markings are often rich, and enhance the value of the Kauri for furniture-wood. Nearest the bark the mottlings are nearly pure bark, and thenceforward inwards nearly pure woody tissue. (Trans. N.Z. Inst., 1874.) This peculiar mottling, due to the mixture of bark-tissue in the body of the woody tissue, is not confined to Kauri: it is most marked in Totara.

A beautiful example of well-figured Kauri is to be seen in the very cramped quarters of the forestry-room of the Lands Department, Wellington—a pathetic little closet, some 9 ft. square, representing all that there is of official forestry in the capital of the Dominion!* This sample, like figured Totara, is cut from a piece of burr wood, and, no doubt, exhibits much more figure than could be expected from selected branch-pieces; but, on the other hand, Kauri burrs are not common, while Totara burrs and excrescences often cover its stem in a remarkable manner. A similar sample in the Dominion Museum represents the totality of wood samples shown there.*

Kauri Value not shown in the Public Museums.

In Auckland I was shown samples of figured Kauri, especially in Mr. H. P. Kavanagh's fine collection, resembling the superb figured Blackwood of Australia. It is unfortunate that in New Zealand the finest samples of the beautiful timbers of the country are scarcely shown in the public museums, whether in Wellington, Auckland, Christchurch,* Dunedin, or elsewhere. Indeed, no museum except that at Auckland and latterly Christchurch has even a third-rate collection of New Zealand timbers, and the timber specimens there are the poorest part of two good museums. Mr. Kavanagh's samples (and there are others like them in veneered furniture at Auckland) let in a flood of light on the really beautiful timbers of New Zealand.

A visitor conversant with the forest wealth of New Zealand, its greatest source of natural wealth, goes away with the impression that these beautiful timbers have been sedulously kept out of sight. The museums seem to vie with one another in ignoring what is usually the first display (out of England) in public museums—the timbers and forest products of the country. Often the wood specimens in New Zealand museums lie worm-eaten and neglected in some dusty basement. I could not help thinking of the story of the Boer children who for two hundred years played with pebbles looking like bits of heavy glass on the banks of the Vaal River! That is forestry in New Zealand for the last fifty years!

In the Dominion Museum Mrs. Blair's recent gift of a handsome cabinet is a gem in a dreary waste of savage trophies. The beautiful woods of New Zealand are unique. Savages, sometimes better and sometimes worse than the old Maori cannibals, still exist in countless millions in all the neglected parts of this globe. For those interested in Maori antiquities one can readily imagine the usefulness of a Maori museum, but what can be said of a *National* Museum that ignores all that is best and noblest in the unique vegetation of New Zealand, the forest—that forest which normally should occupy one-quarter of the area of the country and eventually relieve the country of the burden of the war debt! In the Dominion Museum one looks for a "Forest Pavilion," illustrating the timbers and wild life of the native forest, and elucidating popularly such national questions as the usefulness of the secondary timbers and the handsome furniture that can be made from them, prettier, stronger, and less costly than any of the imported furniture that the public now unwittingly buys, thinking it the best. The peerless character of Kauri among the world's timbers is far from being generally known.

Preparation of Timber Specimens.

I may add a word of practical advice, as I have had a good deal to do with the preparation and care of timber samples.

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* Since improved.

Cut the specimens thin and season very slowly. Put a radial cut into most cross-sections, otherwise it may be impossible to get them to season without cracks. Shape the specimens to show (1) the cross-section from bark to pith and with bark; (2) the slanting cross-section; (3) a board cut radially; (4) a board cut at right angles to the medullary rays. Do *not* varnish the specimens. The grain is best brought up by french-polishing. In the absence of a skilled french-polisher wax or oil may be rubbed in. The simplest and easiest plan is a thin layer of ordinary brown boot-polish. This brings up the grain of Kauri nearly as well as french-polish. Choice specimens such as Kauri veneers should be kept in dust-proof glass cases.

The Forest Office in Cape Town stands in the midst of a wood museum. Mr. R. G. Robinson, the late Chief Forester for the South Island, had a collection of wood samples at Tapanui better than any I have seen in the public museums.

The best timber specimens to be seen now in New Zealand are at the office of the budding Forest Department in the Government Buildings, Wellington. Mr. Phillips Turner has rapidly brought these specimens up to the point of being a thoroughly instructive study.

It will be recalled that when the Duke of Cambridge died a few years ago King Edward presented his residence at Kew to the nation, and it was turned into a wood museum. This has now developed into a good and improving collection of timbers growing and growable in the British Isles. The "Cambridge" Museum at Kew is popular. Classes from the technical schools are brought there for practical instruction. This museum is purely local (British); it is quite outside the great timber collections from all parts of the Empire in the old Kew Museum and at South Kensington.

Now, if England, with its State forestry at least a century behind the best on the Continent of Europe, can have a local wood museum, surely New Zealand, with valuable national forests only awaiting development—forests that will eventually support a population equal to the whole present population of New Zealand ("Forest League" address, July, 1918, p. 3)—should have a national forest museum.

FORESTS AND MINERALS.

Compare the wood specimens in New Zealand museums with those in the Technological Museum, Sydney; and yet only two years ago forestry in New South Wales was behind such little forestry as there is in New Zealand.

A forest court well represented in a museum has a national importance, a public interest, and a nature-teaching far beyond geological specimens, native antiquities, and the trappings of savagery. Sometimes one-third of a New Zealand museum is devoted to minerals, while the total value of all the minerals yet produced in New Zealand is not equal to the value of a dozen medium-sized Kauri forests (Official Yearbook, 1915, p. 606, and the "Value of Puhipuhi Forest," at p. 66). And, what is more, many of the best mines are worked out, whereas, as shown here ("Normal Kauri Forest"), the Kauri forest under cultivation will about quadruple in value in a hundred years. Prussian forests have increased the value of their output more than tenfold in seventy-four years.

Forestry is not a private business, nor does it offer the sensational prizes held out by mining, but its steady yield surpasses mining in the end:

witness the millions put into the coffers of the central States of Europe by scientific forestry, the twenty or twenty-five millions lost yearly by England owing to its want of State forestry, and the six or seven millions paid out yearly by Italy while its forests are developing. In their demonstration of the sensational, and neglect of the solid, it is clear that the New Zealand museums have not the permanent educational value which their general excellence would suggest. (These remarks do not apply to the Wellington and Auckland museums, both of which have yet to be built; while to both I am indebted for important material assistance in my investigations.)

BEAUTIFUL KAURI.

Every one knows Kauri as a useful timber—few as a beautiful one. Sentiment is powerful in every community—the love of the beautiful and what makes for beauty in the homes of a people. If Kauri specimens (and the Puriri that grows with it) with the colouring, depth of grain and sheen that I saw in Auckland lately, were well shown in every museum in New Zealand they would go some way in saving the Kauri forests, at any rate, from the national policy of indiscriminate destruction. Figured Kauri has the property of reflecting light differently at different angles, the general effect being that of a half-hidden ray of light moving below the surface.

Whether owing to the near exhaustion of the forest, or to the practice of decrying New Zealand's most valuable natural asset, its timber,* or whether because there is more profit in importing than manufacturing, these peerless veneers are becoming increasingly difficult to obtain.

J. C. Firth, in his paper on "Forest Culture," read before the Auckland Institute in 1874, lays stress on the waste in not cutting across, and shipping to England for fancy timber, the crutch or point of insertion of the main lateral branches of Kauri. The lateral branches of the Kauri are huge limbs such as one sees on the Outeniqua Yellow-wood in South Africa, and to a less degree on old park Oaks in England. They represent reservoirs of twisted fancy-grain timber.

> The crutch of Kauri is cross-grained, the straight grain of the lower part of the tree being twisted round the knots into a great variety of wavy, transverse, and oblique lines, showing what the cabinetmakers call "figure" . . . Some of the more unique planks or boards might be cut into veneers not only for local cabinetmakers, but sent to London and elsewhere. (Trans. N.Z. Inst., 1874.) The timber in the great limbs of Kauri trees seems to be of finer grain than that in the bole. Thus an average Kauri tree at Waipoua had in a limb I cut across thirty rings per one of radius; but at the base of the same tree and near the bark only, where they would naturally have been narrower, the rings averaged eighteen. Thus the wood in the limb was about twice as "close-grained."

Mr. Phillips Turner tells me that Kauri branch-wood, besides its use for furniture, has had a considerable employment for fence-posts, its wood being more resinous and durable in the ground than ordinary Kauri timber.

There is now a handsome slab of mottled Kauri in the forest office, Lands Department, Wellington. Of all the timbers shown there this specimen holds the palm for absolute figure and colour.

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* Not many years ago a prominent New Zealand politician addressed an important London audience on "New Zealand and its Products." He mentioned products that some New-Zealanders have never heard of, but he clean forgot the Kauri, the forests, and all they were producing, though at the time they were supporting more hands than any other industry.

KAURI NATURAL REGENERATION.

Natural regeneration in New Zealand forests is discussed later at p. 115, and the natural regeneration of Kauri in the Waipoua Forest at p. 28 of "Waipoua Kauri Forest."

Dr. Cockayne remarks (Botanical Report, 1908) that in the Kauri forest he notices usually nothing between seedlings and old trees, whereas outside the forest, in the Manuka scrub, Kauri can be seen coming up in abundance, and here trees of all ages are seen. In the forest Kauri is succeeded by Taraire. I gather that in his view the patches of forest where Kauri is abundant represent a transition period between the open country and the Taraire forest.

How far this may be correct is not of much consequence in the cultivated forest, since it is certain that by lightening the covert Kauri can be brought up in any part of the Kauri forest, provided precautions be taken to prevent the Kauri being dominated by Taraire and other trees of the dense under-forest. Kauri seed will germinate in Manuka scrub, and Kauri saplings will push their way through in the form of long slender whipsticks; but under the dense cover of Taraire and Tawa the seed of Kauri rarely germinates.

Kauri Seed and Fire.—The Kauri flowers in spring, and the seed is ripe eighteen months afterwards, in autumn. Thus Kauri seed is ready just at the right time for ground burnt during the summer. This explains its tendency to good natural regeneration after fires.

Kauri Seed.—There are no male and female trees with Kauri. As in the true pines, the male and female flowers of Kauri are separate, but on the same tree. This is favourable to easy cross-fertilization, which is the best, and tends to give the best seed. But the seed of Kauri is neither abundant nor easy to preserve. Though there is some diversity of opinion as to the keeping-qualities of Kauri seed in the ground, the predominance of opinion is that Kauri seed will lie dormant in the ground for many years. Indeed, were this not so it would be impossible to explain the appearance of Kauri in many places after all possible parent trees had vanished from the locality for years. That Kauri seed may germinate at once or lie dormant for thirty years is the general belief of practical men who have had Kauri under observation. Mr. Karl Qwist, who knows Kauri Gully, near Auckland, very well, is of this opinion, and he showed me a quantity of young Kauri struggling through Manuka, which appeared to support his view. Here the young Kauri is coming up everywhere, except in the dense bush near the stream.

Collection of Seed.—It is not easy to collect Kauri seed. It is shed usually before the cone falls and scattered where the wind may take it; though sometimes a big heavy cone (a globe 2 in. or 3 in. in diameter) may fall and burst open on its fall, scattering the seed in a tempting heap for birds and rats. Under systematic forestry these difficulties will be less, because, the felling of all the trees being regulated, it will be easy to arrange for the felling at the right time for seed of just as many trees as are required for this purpose, and for the getting of them without delay into the seed-beds or preserving sand-layers (stratification).

Says D. Hay in Trans. N.Z. Inst., 1872,—

> The seed is produced in a big round cone, flattened at the top. This falls to the ground when ripe, and, owing to the great height it has to fall, breaks to

pieces immediately it touches the ground, or even before, the seeds then being carried a long distance by the wind. The seeds are flat and very light, with a wing attached to each. The seed vegetates soon after falling. It will not bear being kept dry for any length of time, and is thus difficult to send away.

According to Cheeseman, the cones usually open while still on the tree-tops. The seed-shedding may depend somewhat on the weather; dry hot weather tending to open the cones on the trees, wet stormy weather to make the cones fall whole.

Bunya-pine, the most valuable of the Araucarias, has its cones regularly collected in Queensland. 1½ tons of Bunya-seed was reported sown at Imbil during 1917.

The Kauri Seedling.—"If a seedling be removed from the forest and planted in the open it will assume a reddish hue. To succeed in transplanting seedlings they must be taken out when about 6 in. high, and kept well shaded and sheltered." Thus, D. Hay. He adds that he has had Kauri-pines grow 6 in. or 8 in. the first season. I have frequently noticed the red colour of Kauri seedlings growing in open parts of the forest.

On Ranger Maxwell's Lot 12 there is a good deal of Kauri natural-regeneration saplings and poles. It seems clear that for rapid development the Kauri must have plenty of light, but that for healthy growth when young it must have the moisture, the shelter, and the side shade of the native forest.

KAURI SELF-CLEANING.

Like many of the Australian Eucalypts, like Larch in Scotland (but apparently not in New Zealand), Kauri cleans off its side branches naturally. This is, of course, an important point in the sylviculture of a Kauri forest. It is a quality that, in the powerful light and forcing climate of New Zealand, few trees possess—apparently only Kauri and White-pine among the premier timbers of New Zealand. But for this quality Kauri could not stand out as it does so far above the under-forest. In this characteristic Kauri contrasts very favourably with Oak, which runs out into side branches as soon as the immediate support of the under-forest is removed.

This virtue is of supreme importance for Kauri, because it will in the future be largely propagated artificially by interplanting standards in the bush.

FOREIGN KAURI TREES.

There are many Kauris outside New Zealand, but none equal in size, quality of timber, or value of the resin to New Zealand Kauri. Many species yield resin: *Agathis alba*, of the Pacific islands, produces the Amboina Dammar resin used for varnish; *Agathis obtusa*, of the New Hebrides, is said to grow as tall as, but not to the great thickness of, New Zealand Kauri. The Sydney Botanical Gardens, beautiful of situation, have a poor shallow soil favourable to very few trees. The most remarkable group of trees there are Kauris, indicating perhaps that ability to grow on poor soil is a feature of the genus, and is not confined to New Zealand Kauri. The group of Agathis trees in the Sydney Botanic Gardens show straight pillar-like stems, with smooth blackish bark, and fresh-green thick phyllode-like leaves. The largest tree is *Agathis robusta*, here some 2 ft. 8 in. diameter and 60 ft. of total height. Nearly as large is *A. moorei*, from New Caledonia, and *A. vitiensis*, from Fiji. Smaller trees are *A. ovata*, of New Caledonia, and *A. loranthifolia*, of Malaya.

QUEENSLAND KAURIS.

Queensland Kauri (*Agathis robusta*) is the millers' favourite softwood. It is a good, sound, clear, white-pine timber, but not in the same class as the New Zealand Kauri. It was thus described by R. R. Grundy at the Melbourne Timber Conference of 1916:—

> Queensland Kauri is softer than New Zealand Kauri timber. The tree, though smaller than the New Zealand Kauri, is the largest Conifer on the Australian Continent! It provides the trade with wide boards free from knots or other defects, and stands alone in this respect among the pine softwoods of Australia. For mouldings, turnery, and general joinery work it is considered to be one of the best of softwoods. The timber is easily worked and seasons well. It can be easily stained to any colour, but is more difficult to polish than New Zealand Kauri owing to its more porous texture.

The mature timber of the Queensland Government forests and the timber on private holdings is now nearly all cut out. There is a felling-limit in Government forests in Queensland of 28 in. diameter. Queensland Kauri does not grow as dense as does New Zealand Kauri in full "stand." Thus, although the Queensland tree is inferior to New Zealand Kauri, there is none of the irrational indiscriminate destruction of Kauri that is going on in New Zealand.

The Queensland Conservator, Mr. W. N. Jolly, informs me that this southern Queensland Kauri "coppices splendidly" up to 2 in. diameter. He adds, "When the soil is light, when there is not much undergrowth or too many wallabies, natural regeneration is good. But the young trees must be given light, and when this is done there is liable to be a bad growth of weeds and ground herbage."

There are several specimens of this Kauri in the Auckland parks, where, at any rate in youth, it grows as well as the native Kauri. One of these is shown in Plate V. Its resin is inferior to New Zealand Kauri resin.

Agathis palmerstoni is the giant Kauri of tropical Queensland. It may grow as high as New Zealand Kauri, but its maximum diameter is about half that of New Zealand Kauri. The Conservator of Forests writes to me: "The Queensland Kauri of the north cannot compare with that of New Zealand in size. Clean boles with us might run as high as 100 ft., but the largest-girthed tree I have seen or heard of was about 12 ft. in diameter. It grows freely from seed, but the tropical undergrowth is troublesome. The seed from neither Kauri will keep, but must be used straight from the trees."

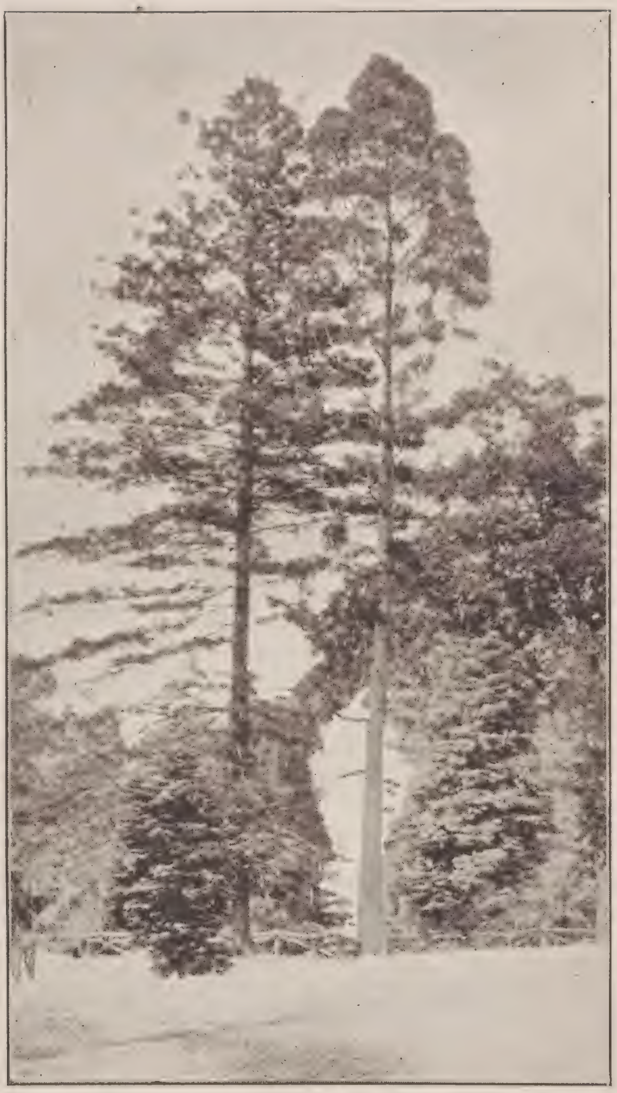
There are two or three species of Kauri in the mountain forests of Borneo, one of these not yielding resin, and another with lumps of naturally exuded resin at the base.

KAURI DISTRIBUTION.

Says Mr. T. F. Cheeseman in his lecture on the Kauri tree: "There are at least eight well-established species of Kauri. Nearest to ours come two species in New Caledonia, and one, or possibly two, in Fiji. There are two in the New Hebrides, two in Queensland, and finally one with a wide range stretching from New Guinea to the Philippine Islands and from Borneo to the Malay Peninsula." This shows an extended north-and-south distribution and a comparatively narrow east-and-west one. (Auckland Institute.)

The Kauri of South Africa.—The tree of the South African forests that in build, longevity, and size so much resembles Kauri is the large Yellow-wood *Podocarpus elongata*. It grows to the size of a big Kauri,

Plate V



Queensland Kauri, *Agathis robusta* (to right), and Norfolk Island Pine, in the Domain, Auckland. The growth here justifies the name of robust.

[*To face p. 28.*

over 11 ft. in diameter, and the giant trees present the same majestic columnar effect that does Kauri. It has supplied between two and three millions of creosoted sleepers of the same value as Jarrah, say the railway engineers. It flourishes on even poorer soil than does Kauri; silviculturally, too, it is like Kauri. Says Sim's "Cape Forest Flora," "The natural reproduction of Outeniqua Yellow-wood is abundant in the Amatolas and Transkeian forests, but is said to be less so in the Midland Conservancy. Its artificial propagation is not difficult, but its after-life is rather slow, and it is not likely to prove a successful plantation tree, though its natural regeneration by protective measures is practicable."

THE DOOMED KAURI.

It has been said by apologists of Kauri destruction in New Zealand that the Kauri is a geologically old tree that has run its course and is destined now to disappear. It has been compared to the Maidenhair tree (*Ginkgo biloba*) of hoary antiquity, now practically extinct as a wild tree, and to the Sequoias in their shrunken habitats.

There are trees in very small island floras that seem incapable of continuance when the least alteration is made in their natural surroundings. The St. Helena native trees died out as soon as goats and Clusterpine appeared on the scene. The South African trees in their present restricted extra-tropical region are delicate trees compared to those of New Zealand, but they lend themselves without difficulty to modern forestry methods, and have been worked and preserved for over a third of a century. Their working is profitable to the Government, and is the chief industry of a district. They have for many years supported a population of one worker per 100 acres. Their largest trees are less than half the size and value of the Kauri. To call the sturdy Kauri a decadent tree is wide of the facts.

The Kauri belongs to an important timber genus (divided at present by botanists into some eight or ten species) which have the appearance of being in the full strength of middle age. As a representative group of vigorous well-grown trees it is doubtful if the various species of *Agathis* in the Sydney Botanical Gardens can be surpassed in Australasia. They all exhibit the smoothish bark and characteristic columnar form of the New Zealand Kauri.

To judge the tree by its relatives and by its own robust growth and fair natural regeneration, Kauri is a tree in its prime. As a planted tree in other countries the Kauri grows vigorously. No doubt the fine Kauri trees in the Lisbon Botanical Gardens (latitude of Rotorua) are known to many New-Zealanders. It seems possible that if New Zealand were to continue to follow the cut-throat policy of Australia up to ten years ago, and complete the destruction of the Kauri forests, it might eventually import Kauri timber from South Africa. As every one knows, this has actually happened with the Australian Black-wattle, Natal now making some £330,000 yearly out of Black-wattle-bark export. Kauri is now being systematically introduced to the native forests of South Africa, where it is nearly certain to thrive in all the wetter areas.

Kauri Photos.—The clearest photographic reproduction of a Kauri forest I have seen is that given at page 16 of the 1909 special Forestry Report of the Lands Department, the best publication so far on New Zealand forestry. This photo shows, on one side, an old "bled"

Kauri, the Kauri "gum" streaming from chips and chops in the bark exactly as one sees it in the forest. On the right of the photo are some Kauri trees in the "ricker" or mast stage, some of the largest of these representing what I have taken as the "Kauri tree of the future." It is reproduced here as the frontispiece.

Future generations may honour the memory of the late Mr. Josiah Martin, of Auckland, for he has left records of the peerless Kauri trees that cannot again be seen for many, many long years—not till the memories of the wicked days of the past, their prodigality and waste (capped by the great war), have mellowed in the brighter days of restored forests, relieving the nation of much of the burden of the war taxes. Amongst Mr. Martin's studies of Kauri trees there is no better than that in the Hon. Pember Reeves's "Long White Cloud." Allowing for a little photographic distortion, it shows the cylindrical form of the Kauri as well as the remarkable photos in these pages.

The best description in print of the New Zealand Kauri tree is that in Cheeseman's "Illustrations of the New Zealand Flora" (vol. 2). There also are beautiful drawings by Miss Matilda Smith, of Kew, showing in detail the foliage, flowers, cones, and seed.

KAURI "GUM."

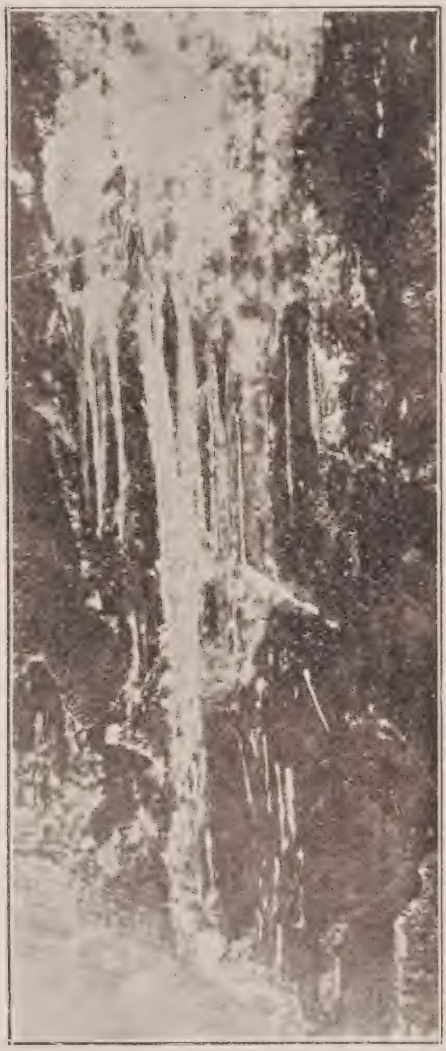
Resin-tapping or "Gum-bleeding" of Kauri.

Generalities.

Says T. F. Cheeseman, "In a fresh state every part of the Kauri is filled with a transparent turpentine, which exudes from the smallest wound. An injury to the bark, a broken branch, even bruised leaves, at once cause a copious flow of the resin." ("Illustrations of the N.Z. Flora," vol. 2.) This is well seen in the photo opposite (Plate VI).

There are two kinds of Kauri "gum"—the ordinary fossil "gum" and tree "gum." Tree "gum" has a strong smell of turpentine; earth "gum" has little smell of turpentine, and is usually harder. Ordinary Kauri "gum" burns as easily as sealing-wax, leaving a dark-brown unburnable residue of about one-tenth its bulk. But the fresh "candle-grease" gum which festoons the side of "bled" trees is more inflammable, carrying fire almost like a train of gunpowder. A form of Maori torture was to burn bits of Kauri resin on the flesh of the victim. Scraped with a knife Kauri "gum" crumbles and smells like a hard sample of the ordinary resin of grocers' shops used for fiddle-bows and fire-lighters. When rubbed it becomes magnetic like amber and picks up scraps of paper. It seems curious that the fossil resin is not called amber. It looks very like amber, and is, in fact, a sort of amber. It is always called "gum," which is just what it is not, because, as they come from trees, gums are soluble in water; resins not. Kauri "gum" can be spun like glass into a fine flossy fibre closely resembling in texture fresh silk from the cocoon. It is stated that in the world's markets Kauri "gum" is supreme. It has ousted all competitors. It is used in making the best varnishes. In french-polishing it is found to combine peculiarly well with linseed-oil. It is estimated that by systematic digging and sifting it may hold that position for forty years more. After having seen the Zanzibar resin trees I can believe this estimate.

PLATE VI.



Kauri resin ("gum") running from a chop with an axe into the bark of a Kauri tree in the Waipoua Forest. This is a fair sample of many others I saw.

Photo, D. E. Hutchins.]

[*To face p. 30*

PLATE VII.

KAURI BLEEDERS AND CLIMBERS.

[To face p. 31.

There is a remarkable collection of Kauri resin in the Agricultural Department, Wellington. It is in two glass cases, and consists of some samples of various sorts of resin—yellow in every tint, and in varying degrees of cloudiness, jet black, and one green-tinted sample. This fine collection was got together for the Panama Exhibition of 1915. The Christchurch Museum shows a huge piece of tree-resin.

What is known as resin-tapping (French *resinage*) is called "gum-bleeding" in New Zealand. The local name rather prejudges the operation, since the sap of the tree is not concerned. The so-called "gum" is resin, and the so-called "gum-bleeding" is more akin to a man's "wiping the sweat from his brow." The Kauri tree, or the man, may be oversweated, but there is no evidence that work in moderation may not be good for both. French foresters state that their systematic resin-tapping seems to invigorate the tree. That it improves the timber is unquestionable: it turns sapwood into wood like heart-wood. ("Australian Forestry," p. 79.)

A Kauri tree can be resin-tapped without interfering with the sap, all the large resin-ducts being in the bark and outside the cambium-layer and sap-circulation. It is not so with the Maritime-pine, the tree of the great resin industry of France; so that here is strong *a priori* evidence in favour of the systematic resin-tapping of Kauri.

Much has been written about the "gum-bleeding" or resin-tapping of Kauri, viz.: Mr. Cheeseman, "The Kauri Tree"; Report of Kauri-gum Commission, 1898; extract from above reprinted in the New Zealand Official Year-book for 1899; Dr. Cockayne's Report on Botanical Survey of Waipoua Forest, p. 4; Mr. H. J. Matthews's Forestry Operations (Rep. Lands Dept., 1905, p. 71).

There is no evidence that the resin-tapping of Kauri, if properly practised, does any harm to the living tree or the timber cut from the felled tree. The mischief that has been done to Kauri trees by "gum-bleeding" seems to be due to the want of forestry and a Forest Department, to see that the resin-tapping was properly done. The resin as it flows from the Kauri trees and hardens usually depreciates in value for want of cupping, and its market price varies according to the amount of bark and dirt mixed with it. It seems probable that the Kauri "gum" from a forest such as the Waipoua Forest would in itself repay a large part of the cost of organizing and working the forest rationally. It is possible that Kauri, like the Cluster-pine (or Maritime-pine) of France, may come to be cultivated with the resin as its chief product. This is one of the important forestry questions that have been awaiting investigation by foresters for half a century in New Zealand!

The remarkable photo opposite (for which I am indebted to Mr. Skeet, the Commissioner of Lands, Auckland) shows what mischief may be done to a Kauri tree by unrestricted "gum-bleeding." It is easy to see how a vigorous young tree attacked in this way must suffer, especially when the gashes the "bleeders" have there made, and which, it will be observed, are running freely, come to be enlarged. Usually the gashes are confined to the base. Trees are often completely girdled by such gashes. Then the circulation of the sap is interfered with, such timber becomes half-dry, the tree "stag-headed," and eventually it dies. In Waipoua, where there has been little "gum-bleeding," I estimated the proportion of dead Kauri trees at 4 per cent. (See p. 27, "Waipoua Kauri Forest.")

"Gum-bleeding," as practised by the Kauri "gum-bleeders," is what the French call expressively *gemmage à mort*—viz., tapping to death. Though this bleeding, unless it is accompanied by ring-barking, does not usually kill the tree, it certainly deteriorates the timber and affects the growth of the tree. Just what mischief it does depends on how badly it is executed.

If it were proved to injure the timber, comes the question how long before felling can the tapping be done without danger to the timber? The Kauri Timber Company have recently given out an extensive contract for Kauri-bleeding to be done within the year preceding the cutting. I hear, too, of *gemmage à mort* being practised in some good Kauri forest left at Paramatau, on the east coast. The forest there has been sold, and the miller has let the bleeding-rights before he fells for milling.

Attitude of Land Commissioner, Auckland.—There can be no doubt that until a Forest Department is organized, and the Waipoua and other forests come to be in charge of trained foresters, the Commissioner and the Lands Department, Auckland, are right in setting their faces like steel against any more promiscuous "gum-bleeding."

"Gum-bleeding" is interdicted under the present Forest Regulations.

Yield of "Gum."

I have heard of one Kauri forest with 30 million sup. ft. of Kauri with the "gum-bleeding" rights to crown and branches let at only £1,000 yearly. I have heard of another forest where similar bleeding-rights for a year before felling were let at not more than 1 per cent. of the value of the timber; and even this partly because the lessee would act as a Forest Ranger and keep out illicit "gum-bleeders."

Naturally the profits of "gum-bleeding" confined to crown and branches must be small. That it should be profitable otherwise is shown by the eagerness of the illicit "gum-bleeder" to get at the trees and take his harvest. The profits would be greater still in an organized forest, easy to get about in, with roads and paths but little undergrowth, and with a settled population, where women and children (greatly to their health and well-being) could collect the resin, as they do in France, and as Ranger Maxwell's children do now at Waipoua.

The resin-yielding of Kauri varies more than that of Maritime-pine in France. Some trees are dry—they may be hacked all round and give no resin; others pour forth as soon as they are touched. The subject requires investigation by scientifically trained foresters.

Kauri trees are estimated to yield from 10 lb. to 50 lb. each yearly of bled "gum," and 3 lb. or 4 lb. of naturally exuded "gum." This is double or treble the yield, as appears below, of the Indian Chir-pine, which is now being systematically tapped by the Indian Forest Department with increasingly successful results.

"Bled Gum."

The total export of "bled gum" at present is, I understand, only about £5,000 worth. Apparently the resin-tapping of Kauri is an industry capable of great development. I have the statement of a "gum-bleeder," confirmed by a "climber," through a reliable source, that they can average £5 worth of "gum" per year per tree, with trees bled twice a year. This would be for largish trees worth some £30 each for timber. Thus the value of the "gum" would be equal to the value of the timber in six years, supposing that it were advisable to continue the bleeding for six years without a period of rest.

Up to twenty years ago "bled gum" had no value. Then, about 1909, on an ill-starred day, the Government started "gum-bleeding," giving, it is said, one Dysart the right to bleed 300—and he bled 3,000—trees. A lawsuit followed, but the bad practice of unregulated "gum-bleeding" was started, and has continued ever since.

Good average "bled gum" was worth from 6d. to 1s. a pound when the war started. Present quotations for good "bush gum" free from the dirty "bled gum" are £125 per ton, or 1s. 1½d. per pound. It is in good demand, say the Auckland "gum" merchants. Prices quoted at Waipoua are: Tree "gum," from 1d. per pound (for the dirty "gum" picked off the ground) to 1s. 7d. per pound (for the hard old clear "gum" found in the forks of old trees). Tree "gum" has an acidity from which the earth "gum" is free.

Value of Kauri "Gum."—I hear of first-class white, clear, fossil "gum" worth £600 per ton—say, 4s. 6d. per pound. (Trounson and Carroll). Ordinary earth "gum" varies in price from 1d. to 2s. per pound. These are prices on the gumfields. The "gum" varies greatly in value: a "gum-digger" may get ten or more grades in a week's work. The export figures for the last year before the war show that the average value of all the "gum" exported was only 7d. per pound. Thus carefully tapped and cupped tree "gum" should average a higher price than the general average for the "gum" now exported. Prepared as at present, Kauri tree resin is said to average only about half the price of mineralized resin on the Auckland market.

Putting the timber out of the question, it is difficult to see how Kauri resin-tapping can be otherwise than a very profitable industry. Compare it, for instance, with sugar. That takes a great deal of labour (some half of it in a climate that is exhausting for a white man), costly milling, and then refining, which is an art in itself. The product is worth 1½d. or 2½d. per pound, pre-war, wholesale; Kauri "gum," with little more than light work for women and children, 1s. per pound. Sugar grows on the best soils, Kauri trees on the worst.

Or Kauri resin-tapping may be compared with hop-growing; its risk and expense, with the ease and certainty of resin-collection. Hop-picking is one of the very few healthy outdoor industries left to women and children in England. It is prized highly in the rural districts of Kent, and described as "£15 in pocket and health for a year."

Opinions on Kauri "Gum-bleeding."

As regards the effect of Kauri "gum-bleeding" on the timber I have received many opinions. "With precautions" the Hon. E. Mitchelson is not afraid of it. Naturally, official opinion just now in Auckland is not favourable to resin-tapping, but it must be remembered that a roving commission to a professional "gum-bleeder" is quite a different matter from departmental work under skilled supervision. Too little distinction has been made between *gemmage à mort*, or death tapping, and *gemmage à vie*, or life tapping. This is literally a matter of life and death for the whole process. The conclusion arrived at in the Lands Department, Auckland, influenced no doubt by the advice of its late timber expert (Mr. H. P. Kavanagh), is that the resin-tapping of Kauri is destructive to the timber, even when the tapping is done with narrow slits, and using all practical precautions possible. It is considered that once the bark is cut through and the living sapwood reached, the resin ("gum") runs out like water from a sieve! If, on the other hand, very narrow slits are made the tapping will not pay expenses. I may say at once that my preliminary experiment does not confirm this view.

The general opinion among the Kauri timber-workers and Kauri companies seems to be that "bleeding" renders the timber brittle, and if Kauri "bleeding" is allowed at all it should be restricted to the crown. Exact experiments have not yet been made to ascertain whether this belief is founded on fact, or whether it is assumed to be so, because the timber that has been bled badly tends to become bored, and thus more brittle.

It is difficult to see how resin-tapping can injure the Kauri timber being felled now, since the old trees of the virgin forest are nearly all heartwood, and heartwood is dead tissue. Whatever its qualities, good or bad, they were settled long ago, and will not be altered now by the little ring of live tissue on the outside, the sapwood, supposing for the sake of argument that the sapwood were affected by the resin-tapping.

Gemmage à vie would require ten or fifteen years to investigate. Groups of Kauri trees would have to be variously tapped, the timber cut up after an interval, and regularly tested.

The late Mr. Matthews (Lands Yearly Report, 1905, p. 75) quotes Ranger Lusk's opinion with regard to bleeding: "I have given," says Mr. Lusk, "the subject close attention, and I am of opinion that Kauri trees may be tapped without injuring them (or the timber), but if the work is carried on in a rash and careless manner the trees and timber would undoubtedly suffer."

It is difficult to believe that the resin-tapping of Kauri, properly done, and in moderation, can harm the timber, because, as has been seen, the Kauri tree in a state of nature sheds its "gum" naturally. A Kauri-climber will get £1 or £1 10s. worth of "gum" from the crown of a big Kauri, as a matter of course, without any broken branch or decay, or special cause to account for the exuding of the resin ("gum"); and at the end of a few years the Kauri-climbers will go up the same tree and get another £1 or £1 10s. worth of "gum" from the branch forks.

"*Gum-bleeding*" *or Resin-tapping in Other Countries.*

France.—In France the resin-tapping of Cluster-pine has been practised since the time of the Romans. The great resin industry of Gascony need only be referred to here: it is well known from numerous writings in both French and English (see "Bibliography" in Part II of this work—separate publication). Just before the war broke out I had a forest tour in Gascony ("Australian Forestry," pp. 80, 259). Resin-tapping there is like picking apples from an Apple tree: it is done as a matter of course. If a man has half a dozen pine trees in his back yard he will tap them. The Maritime-pine (Cluster-pine, *Pinus pinaster*) and resin-tapping are to Gascony what wool is to New Zealand in wealth, *but the forest affords very much more employment*. The Pine-resin industry is practised along with sheep and cattle raising and crops. Farming and forestry are worked in together, the forest providing most of the fertilizer for the poor sandy soil, the pine-litter being passed through the stables. There are farmers in all degrees, from the peasant to the wealthy country gentleman. It is always intense farming and close occupation. The resin industry as it affects Australia is discussed in my "Australian Forestry," p. 80 (Perth, 1916). The extraordinary fact is that New Zealand, endowed with these Kauri forests, where both timber and resin are of at least twice the value of Maritime-pine, can for sixty years have allowed the population and wealth of Gascony to slip through its fingers; and, what is worse, the forest to be destroyed for (taking Puhipuhi figures) less than 1 per cent. of its present-day value as a dividend-earning forest estate!

The Maritime-pine forests of Gascony were lost during the wars and misgovernment of the Dark Ages, but have been replanted in modern times, the cost of replanting being about the same as the cost of interplanting Kauri in New Zealand forests. The French have spent over £2,000,000 in planting and roadmaking there since I was a boy, and they now draw £18,000,000 yearly in resin and timber from these forests, the resin being the most valuable product. This great forest work was begun on the initiative of a peasant, and then taken up by the Government through its Forest Department. The story is well told in a charming French novel, "Maitre Pièrre," by Edmond About.

A short account of the French system of resin-tapping is given in Recknagel's "Working Plans," p. 142.* The resin is kept pure and clean by being caught in cups. Trees are not tapped till they are 11 in. diameter, and not more than three cups are put on one tree at any time. The slits are made narrow and gradually extended up the trunk for six years to a height of 7 ft. or 8 ft. above the ground. The tree then has three years rest. Then three more fresh slits are made between the old slits, and gradually lengthened as above. Thus each tree goes through twelve years' resin-tapping with a rest of three years in the middle, making fifteen years the total resin-tapping period for each tree. Then the trees are cut for sawing into timber, sleepers, or pit-props, the timber being improved by the resin-tapping, which has the effect of making sapwood nearly as durable as heartwood.

Portugal.—The forest of Leirìa, north of Lisbon, is the pride of Portuguese foresters, and one of the best-managed forests in southern Europe. Maritime-pine (*Pinus pinaster*) is there grown for timber, not for resin, and the timber is unsurpassed in quality. Nevertheless trees going out in the thinnings are regularly resin-tapped for three years previous to felling. A big cut about 3 in. broad, 18 in. high, and 1 in. or 1½ in. deep, is made at the foot of the tree—two or three of these cuts each year according to the size of the tree. I counted six resin-cuts on a 22-in.-diameter tree. I have a photo showing eighty-year-old trees that have been resin-tapped for three years and will be felled next winter.

Germany.—In Saxony, where the forests have been systematically managed for two hundred, and sometimes three hundred, years, Spruce, which is full of resin, has long been systematically tapped. Twenty-seven years ago, when I visited these forests, the tapping was coming to an end, because it did not pay compared with the yield of resin from more southern forests, Cluster-pine in Gascony, and the Long-leafed Pine in the southern United States. The tapping sometimes caused rot in the Spruce, possibly because the slits were made too broad in the endeavour to get a paying crop.

India.—In India resin-tapping is being practised increasingly and with the best results. (See Forest Bulletin No. 26 of 1914, "The Resin Industry of Kumoan," and "Indian Forest Memoirs: *Pinus longifolia*," by R. S. Troup, F.C.H. The latter is in the Lands Department Forest Library.) Chìr (*Pinus longifolia*), the most important Indian pine tree, covering an area of two or three million acres, yields an average of about 6 lb. per year per tree tapped. This tree, in its wetter areas, grows in the same climate as that of Waipoua. They have there adopted the French system of tapping, modified to suit local requirements.

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* Also Veitch's Coniferae, p. 93.

From a comparative small belt of pine forest along the lower western Himalayas French-trained forest officers have worked up an industry producing near 3,000 tons yearly of resin, and employment to over 2,500 workers. The net value of the resin is about a twenty-fourth that of Kauri resin.

It is stated (p. 45, "Work of the Forest Department in India") that the Indian Forest Department is laying plans to capture the Australian and New Zealand markets, and till the days of better forestry in these countries no one can grudge the Indian Forest Department its success.

America.—In America (whence comes most of the sadly large import of resin to New Zealand) the tree that yields most of the resin is the Long-leaf Pine of the Gulf States. This Long-leaf Pine forest is in a very wet, warm climate almost exactly that of Waipoua; and this tree, being slower-growing than Kauri, could be introduced into Kauri forests without danger to the Kauri. American resin-tapping has not much interest from a forest point of view; its methods are primitive, and it generally ends by destroying the forest. Details will be found in the American Forest Service Bulletins.

As in France, there are large areas, especially in Florida, where resin-tapping is the most valuable industry. The Long-leaf Pine (*Pinus palustris*) is the best of the pitch-pines, and one of the strongest, least perishable, and generally useful of all pine timbers. The practice is to tap the pines for three or four years before felling. Say F. Moon, Professor of Forest Engineering in the New York State College of Forestry, and N. Brown, Professor of Forest Utilization, "Tapping for turpentine does not injure the quality of the wood for lumber or other wood uses."

The quick-growing Cuban-pine (*Pinus heteraphylla*), yielding over £2 per acre per year for resin, can be tapped for twenty-five to forty years without appreciably lessening the value of the tree. ("Journal of Forestry," Washington, March, 1917.)

Canary Islands.—Resin-tapping was started on the Canary-pine when I was in Tenerife a few years ago. Here it was being as badly done as the early Government Kauri gum-bleeding at Auckland, which led to so much trouble afterwards.

Insignis-pine Resin.—The Insignis-pine yields a fragrant resin, and, judging by a tree I saw barked at Dargaville, seems to stand the severest form of tapping. The resin has been extracted experimentally in South Africa. When Insignis-pine comes to be largely planted in New Zealand its systematic tapping may develop into an industry.

THEORY AND PRACTICE OF "GUM-BLEEDING."

It seems plain to me that the value of the "tree gum" in the Waipoua Kauri Forest may go a long way towards the whole cost of organizing the forest, even if the resin-tapping were only confined to tapping the trees marked for felling. If a Kauri "gum" climber can earn up to £10 or £12 a week, this is practical proof of the value of the "tree gum." It may be objected that labour in New Zealand is double the price of labour in France. To this there is the answer that Kauri timber and Kauri "gum" are two or three times the value of the resin and timber of Maritime-pine.

Resin-tapping may be looked at under four aspects:—

(1.) Resin-tapping shortly before a tree is felled (*gemmage à mort*). If properly conducted this can hardly possibly injure the timber, and there does not seem much chance of its doing so, even if badly conducted.

(2.) I believe also that, employing narrower slits than the French practice (*gemmage à vie*), resin-tapping will not injure the timber at any time. It is a point to determine just how wide the slits should be made, so as to let out the resin freely and at the same time prevent the entry of wood-borers. My experiment seems to show that the slits may be very narrow.

(3.) There is another question: Will it improve the timber as it certainly does in France with Maritime-pine?

(4.) And lastly comes the interesting speculation whether, if resin-tapping is done so as to exclude borers and fungoid rots, it may not promote a more vigorous growth of the Kauri tree itself. French forest officers have assured me that careful tapping actually promotes a better growth of their Maritime-pine.

FUNCTION OF RESIN.

Resin-tapping invigorating.—It is an interesting speculation whether, with moderate "tapping," letting off the surplus resin may not actually help the vegetative process of the Kauri tree.

We know that the growth put on to the stem of a tree is formed by the descent of nutritive material from the leaves and boughs; that the boughs in Kauri trees after they have passed the "ricker" stage are very well developed; that in consequence the tree continues to grow rapidly at the base, and very rapidly in the part of the bole near the crown (this is shown by studying the rings). We know also that all the growing parts of Kauri trees are imbued with the resin, which is thrown off when and where the vegetative process is most active. Some trees, as most conifers, keep a good deal of resin in their timber, but many, especially non-conifers, throw it off altogether—the wild Mango, for instance, into its fruit. In many other trees and smaller vegetation, the bark, or leaves, or fruits taste strongly of resin, and this in situations where the plant derives no benefit from its being there. It has been thought that resin was a protective secretion, but this theory is far from according with all the facts. It seems much more likely that resin is a by-product of the vegetative process, and that trees throw it off as soon as they conveniently can. At any rate, that seems to be the case with the Kauri. There is little or no resin in its timber; its bark is full of resin, which it gets rid of at every opportunity. The largest and most active of the resin-ducts seem to lie about the centre of the bark, which in Kauri is nearly all live bark.

It is a fact in systematic resin-tapping that when it is first commenced the trees respond to the tapping as if they liked it—the flow of resin gradually increasing for two or three years. If the resin-tapping be carried to excess the tree becomes injured in its growth, but will recover, unless the resin-tapping has been carried to great excess, the *gemmage à mort* of the French. But after all, this is the common effect of a tonic in medicine. I see no reason why light tapping should not act as a tonic to Kauri, encouraging a more vigorous growth.

Thus, getting back to the French foresters' theory, if some of the resin were removed the nutritive material from the boughs of Kauri might descend more easily, and thus the growth be stimulated. At present it is abnormally large near the crown.

Resin Preservative.—The preservative effect of resin seems to have been exaggerated. The result of a recent research published in the *American Lumberman* of the 27th January, 1917, is that resin does little in excluding fungoid rots from wood. I know as a fact, after handling Cluster-pine for thirty years, that there are few timbers that more easily take fungoid rots or boring-insects; and Cluster-pine (*Pinus pinaster*) is full of resin in all its parts. It must contain two or three times the quantity of resin in Kauri; and, as above, yields a large part of the resinous products of the world.

Stone-pine (*Pinus pinea*), which I know equally well, is similarly resinous and similarly perishable. The Pitch-pines of the southern United States have similarly a limited durability in the ground.

The resin poured out by Kauri when it is cut protects the interior tissue mechanically; but I have no doubt that the Kauri owes its durability to some substance in its timber other than resin. The hard crystalline resin thrown out by the Kauri tree looks at first sight as if it were a provision of nature enabling the tree to defend itself against borers and fungoid rots. But against this there is the fact that borers do not go into the live bark of Kauri, though they go into the dead, full as it is of resin. It is much more likely that Kauri resin is a by-product of the tree's vegetative process, and is thrown off at every chance the tree gets of a convenient exit, such as from the bark-cracks in the crown formed by the swaying of the branches.

Resin a By-product.—Resin is formed as a by-product during the transformation of food materials, such as starch, into woody tissue. (P. 10, Bull. No. 229, Forest Service, U.S.A., 1915.)

In pine trees, where resin-formation has been studied in Europe, resin is formed in a small way at all times in the resin-ducts; in a large way after a tree is wounded. After a wound the resin-ducts enlarge and secrete a plentiful supply of resin. This takes place chiefly in the cambium layer and outer layers of the sapwood. These secondary resin-ducts are longer above than below the wound. It takes from two to four weeks for these ducts to form and fill with resin. It is they that produce the bulk of the resin of commerce.

The French or "light-tapping" system consists in making a slit 4 in. wide and about ½ in. deep into the sapwood. The slit is gradually prolonged upwards for four years or more and then allowed to heal over. The French system does the trees no harm.

The old American plan in Florida was to make great gashes in the sides of the trees and a hole (the "box"), in which the turpentine collected. This killed the trees, either directly or indirectly, by disease, fire, and windfalls. The French system of "light tapping" and the collection of the resin in cups is now being slowly introduced to America.

Crown Deposits.—Kauri in its vegetative process—in virgin forest untouched by the axe—will throw off resin ("gum") from cracks in the stem, and will form huge deposits in its crown at the juncture of the branches where these are swayed and strained by the wind. These crown deposits of Kauri "gum" may reach the size of a two-year-old child, and a "gum-climber" may earn £10 or £12 a week getting them. They have been called humorously the nest-eggs of forestry! 80 lb. is claimed as about the maximum size for the lumps of resin produced naturally in the forks of living trees, and 200 lb. (some say 300 lb.) as the maximum size of lumps in the ground. The discrepancy in these figures is not easy to account for. It is thought to be due to two or more lumps running together. Old "gum-diggers" have assured me that Kauri resin from green trees has the property of running together after some time into one solid mass.

A curious belief which Kirk asserts as a fact ("Forest Flora") is that ground which has been thoroughly turned over (as carefully as a potato-field) and had all its lumps of resin taken out will, after some years, yield another crop of resin lumps!

The well-grown foreign Kauri trees in the poor soil of the Botanic Gardens, Sydney, are described at p. 27. This ability to thrive on very poor soil may be connected with the abundant production of resin in Kauri trees; and it is worth noting that the world's two chief resin-producing pines, *Pinus palustris* and *P. pinaster*, are both remarkable for growing well on very poor barren sandy soils where few other trees can grow at all—white drift sand with clay below, the actual soil where Kauri flourishes near the coast at Waipoua.

Conclusions.

The general aspect of resin-tapping in other countries is that whereas formerly it was done indiscriminately, and ruined much good forest, it is now being increasingly done under proper control, to the good of the forest revenue, and without harm to the timber. In France, and latterly in some of the Indian forests, the forest revenue is greater from the resin than from the timber. In Gascony resin-tapping improves the timber undoubtedly, and is believed to improve the growth, acting as a tonic. The industry there goes back to Roman times.

I see no reason why resin-tapping in the future Kauri forests of New Zealand should not be as lucrative as in Gascony, where as an industry it compares with sheep in New Zealand, affording, however, considerably more employment; in fact, to a large extent it has replaced sheep there. Gascony under sheep was a desert compared to what it is now. Few of the picturesque shepherds on stilts are now seen; but one can travel for a whole day, in a quick train, through an endless succession of farms where, as mentioned above, ordinary farming and resin-tapping work in together; and all this in the climate of the Canterbury Plains!

My Experiment on Kauri Resin-tapping.

"Gum-bleeders" and bushmen in Auckland are agreed that the Kauri "bleeds" only from the cut bark, never from the wood. It is thus not clear how, as is alleged, "gum-bleeding" can injure the timber. It seems that what is required for rational Kauri resin-tapping is a man able to use a light sharp axe so as to open out thin wedge-shaped slits through the bark, barely touching the wood, such slits being lengthened, and lightly scraped or shaved clean, from time to time ("refreshed," as the French say), so as to ensure the continual flow of resin, without having a slit at any time as wide as in French resin-tapping, which in Kauri would risk the borer getting in.

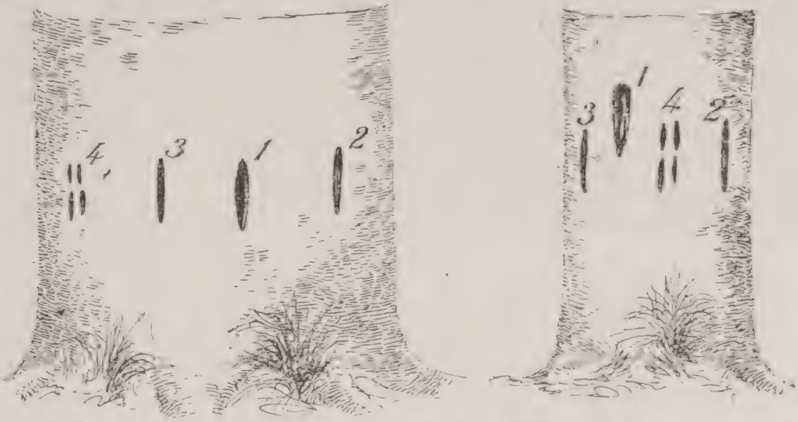
It seems likely that indiarubber-tapping in the future may take the form of bark-pricking rather than of bark-cutting, and that may be the case with Kauri resin, cleaning it perhaps by a recently described process.

It is stated that the practice, in illicit "gum-bleeding," of cutting a large notch in the trees is simply as a receptacle for the resin, like the American "boxes" used in tapping Long-leaf Pine. Some receptacle is required to catch the gum, and probably old jam or other tins would be sufficient for the purpose. There are piles of such tins in the refuse-heaps of New Zealand towns not using destructors. In South

Africa such tins are gathered from house to house by collectors, or from the city refuse-heaps, and employed in the nurseries.

Experimental Tapping of Two Trees.

While at Waipoua I made a small "gum-tapping" experiment on two trees. The form of the slits made is shown on the accompanying sketch. After twenty-four hours the slits showed the following results:—



(1.) A slit, made like Maritime-pine is tapped in Gascony, but rather longer and less wide, in order to prevent the access of the borers. The Gascony resin slit is 5 in. or 6 in. long to begin with, about 3 in. or 4 in. broad, and goes through to the wood. It is gradually "refreshed" till it becomes a slit several feet in length. My slit was 1 ft. long and 1 in. wide, exposing the wood. This slit showed only a small flow of resin at the time, but after twenty-four hours there were some three tablespoonfuls of a creamy "gum," all of which it was clear had flowed from the bark, and most from the inner bark.

(2.) (See diagram.) This was a slit made with a sharp pocket-knife, about 1 ft. long and 1 in. broad, just penetrating to the wood, and where it cut through the cambium-layer about $\frac{1}{16}$ in. broad. An hour afterwards the bark showed white beads of resin distributed almost equally over the bark, which is here $\frac{3}{4}$ in. thick and all live bark. There is little chance of the borer getting in with such a slit, as the wood is only slightly exposed. It was remarkable that *after twenty-four hours there was as much resin exuded from this narrow cut as from the broad Gascony cut.* The resin had exuded about equally from the inner and outer bark.

(3.) This was made with a sharp knife, like No. 2—viz., a strip about 1 ft. long and $\frac{1}{2}$ in. broad, but instead of going through to the wood it only penetrated the outer half of the live bark. This started running milky juice similar to No. 2, and after twenty-four hours had nearly as much resin exuded. For the size of the cut this was the best after No. 4. The slit was full of "gum" except on the upper part, and a streak of "gum" 4 in. long had run down the tree below the slit.

(4.) This has given by far the best results. It consisted of four cuts with a sharp axe, side by side, through the bark and on to the wood. This leaves a slit like a mere crack in the bark. An hour afterwards there was a scarcely perceptible appearance of milky juice. But after twenty-four hours *this, for the size of the slit, showed the best yield of resin.* Each axe-cut had a long strip of "gum" running out below it; one of these 22 in. long, $\frac{1}{2}$ in. broad, and $\frac{1}{4}$ in. thick. From these four axe-cuts there were about three tablespoonfuls of resin. The chop with the axe is done in a second, and the cut left by the axe is so small, and the resin that comes from it so abundant, that all fear of the borer getting in has vanished.

All the above relates to a young cylindrical-boled tree 3 ft. 7 in. in diameter.

The old tapped Tree.—As shown by the diagram, the cuts and slits I made on the large old tree were similar to those on the small one. This tree had a diameter of 8 ft. 1 in. and a bole of about 35 ft. It had been heavily tapped in the past, and all round the base showed drippings of "candle-grease gum," though the tree itself showed no sign of having suffered from its bleeding in the past.

My cuts on this tree, although in all respects exactly like the four slits or cuts in the smaller tree, gave practically no yield of resin.

Situation.—These two trees are situated within 15 ft. of one another, within the demarcation-line of the top boundary of "Hope Block" on the demarcation plan. They are near the bridge on the short path leading from the trigonometrical station "Pawakatutu" to Ranger Maxwell's Lot No. 12.

Results to the end of Summer.—Since I left the Forest Ranger has reported regarding the further flow of resin from my experimental cuts. He does not differentiate between the cuts, but says generally that the "gum" has run down freely from the cuts in long candle-like formation. This settles the important point as to the free flow of "gum" from slits made very narrow so as not to permit of the entry of the borer, with perhaps the exception of the French slit. As usually happens, with the advent of winter the resin ceased to run. The cuts should be "refreshed" next spring and the flow of resin recorded.

"GUM-DIGGERS," AND NATURAL REGENERATION OR TREE-PLANTING.

It is not necessary here to more than allude to the great possibilities in natural regeneration and tree-planting which are offered by the operations of the "gum-diggers." (See p. 117, "Wounding the Ground," and "Natural Regeneration.") Either by "gum-diggers" under control, or working departmentally as with the Kauri-gum Department and their ground-preparation, it may be possible to get large areas of soil-preparation done at comparatively small cost. This is brought home to one very forcibly in seeing the "gum-digging" which had begun in the Waipoua Forest, and was stopped years ago to save the forest. The idea of combining Kauri "gum"-digging with tree-planting is no new one: it is frequently mooted in the Report of the Royal Commission on Kauri-gum Reserves in the Auckland Lands District, 1914. The great possibilities it offers when once fairly systematized are obvious. Nothing, of course, can be done till a Forest Department on the usual lines is organized.

The best short monograph in print on Kauri trees and resin is that prepared four years ago for the Panama Exhibition—though there is a misprint of 40 for 14 on the first page, while the continued destruction of the Kauri forests is passed over in silence, and the growth of the tree misstated. Some of the more important facts mentioned in this pamphlet are these: Area of Kauri gumfields about a million acres, of which about half is privately owned. Price of Kauri "gum" varies from £300 to £5 15s. per ton; one-third of a million tons, valued at £16,000,000, has been exported. In 1913, 4,000 tons went to America and 4,500 to Europe. From five thousand to six thousand people, male and female, get a living out of Kauri "gum."

KAURI: THE LARGEST TIMBER-YIELDING TREE IN THE WORLD.

Two Important Facts about Kauri.

Mr. Cheeseman's investigation into the growth of the Kauri, its comparatively quick growth, and its life shorter than has been currently stated, was published on the eve of the outbreak of war, June, 1914. It thus escaped the notice it deserved, though it is possible that the importance of the discovery might not have been appreciated till the "Transactions of the New Zealand Institute" went abroad and got circulated amongst professional foresters.

Since I spent my five weeks amongst the Kauri trees at Waipoua another startling fact has come out. *Kauri, according to the records, is the biggest timber-tree in the world*—the tree that yields the greatest bulk of timber!

The big Eucalypts of Australia are much taller, the big Sequoias of California have stems averaging somewhat thicker and a good deal taller, but neither of them carry their thickness up like the Kauri. It is the shape of the Kauri trunk that gives to it its unprecedented volume of timber. As will be seen below, when one compares the bulk of commercial timber in the biggest recorded Kauri tree with the official record of the timber in the largest "big tree" of the Calaveras Groves, *the Kauri has rather more than twice the bulk of timber!*

The big trees of California and of Australia have been the subject of exaggeration. This is natural; but the depreciation which, as I have shown elsewhere, characterizes the published descriptions of New Zealand trees is not easy to understand. Book after book has assigned heights to Kauri, White-pine, Rimu, and the glorious Beech forests of the south which are two-thirds or three-quarters the real heights of the trees. Possibly the writers have confounded bushmen's measurements of bole-heights with total heights. My measurements were taken with a verified angular instrument, and this has been confirmed, in one instance at least, by theodolite and chain measurement by Mr. Phillips Turner, a professional Government surveyor.

Kauri Stature.

The largest authentic Kauri tree commonly mentioned in New Zealand literature (New Zealand Year-book, &c.) is that at Mercury Bay, stated as having been 24 ft.* in diameter. Dr. Marshall's popular "Geography of New Zealand" (p. 323) puts on another foot. Kauri "trunks are occasionally 25 ft. in diameter," he says. Popular writers speak of Kauri boles up to 31 ft. diameter. ("New Zealand in Evolution," by Scholefield.) When in Auckland I tried to see the Mercury Bay tree, but was unable to get further particulars regarding it than that it is believed to have been burnt. Kirk, at pp. 144–145, "Forest Flora," mentions a tree at Mercury Bay 24 ft. in diameter and 80 ft. bole, and another at Maunganui Bluff 22 ft. in diameter.

Kairaru: Diameter, 22 ft.—Mr. H. P. Kavanagh, late Chief Timber Inspector, Auckland, considers that the largest Kauri trees of which the growth has been accurately recorded are those that grew in the

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* Mr. Percy Smith, late Surveyor-General, tells me that it was common knowledge in the "sixties" and "seventies" of last century that there was a huge Kauri tree growing on the mountains at the head of the Tararu Creek that falls into the Hauraki Gulf, just north of the mouth of the Thames. "This tree was stated by those who had seen it to be 28ft. in diameter."

Tutamoe Forest, near the Waipoua Forest, and which were measured by Ranger H. S. Wilson. The largest of these two trees, on the east side of the Tutamoe Forest, was called "Kairaru"* by the Maoris, and measured *22 ft. in diameter, with 100 ft. of bole to the first branch.* This, therefore, was the record big Kauri tree of New Zealand, and the biggest timber-producing tree in the world! If sawn up without waste in a good mill, as calculated below, it would have yielded 221,841 sup. ft. of sawn timber; or, taking a common American log rule, 213,333 sup. ft.

The other large tree in the same forest, which also had a special Maori name, "Nga-mahangahua," was of the same diameter, but this forked at a height of 22 ft.

The Hon. E. Mitchelson quotes as the thickest Kauri he has known a tree in the Mangakahia district, which was 16 ft. in diameter. It was left standing as being too large for milling purposes, and was afterwards burnt.

Mr. W. B. Buckhurst sold a giant Kauri at the headwaters of the Wairoa River which was 20 ft. in diameter and had 60 ft. of clean bole.

At page 8 of the Lands Department yearly forest report for 1907 (C.-4, Timber Industry) is shown a photo of a large Kauri tree 16 ft. in diameter and 42 ft. in length, containing 78,750 sup. ft., at Matakohe.

Height, 275 ft.—Charles Darwin has recorded 90 ft. of clean bole as occurring in the virgin forest; Kirk, 100 ft. bole as the official measurement of the giant Kauri tree "Kairaru"; and of other trees, the tree with the longest bole of which I have heard is stated by Ranger Maxwell, of Waipoua, to have been some 125 ft. It cut up into four lengths of 30 ft., so that it must have been at least 125 ft. long. Mr. Mitchelson tells me that the longest Kauri spar he has known was 124 ft. Colenso mentions a spar free of knots, and therefore cut out below the crown, which was 106 ft. in length. He gives 200 ft. as the maximum height of the Kauri tree generally (Trans. N.Z. Inst., 1868).

Of the total height of big Kauri trees I have no records. The loggers and millers do not look above the top of the bole. The trees I saw in the Waipoua Forest had usually about half their height in their crowns. Applying this rule to Ranger Maxwell's tree, it would be some 250 ft. in height. Probably one may take the maximum height of the New Zealand Kauri at its best as having been about 275 ft.

AUSTRALIAN GIANT TREES.

The big Australian trees are discussed in an interesting pamphlet by Mr. A. D. Hardy, of the Victorian Forest Department (Annual Report, Forest Department, Victoria, 1910–11); and in my "Australian Forestry," p. 315. It is probable there are or have been Australian Eucalypts with a total height of 400 ft. It is certain that there are trees now up to 350 ft. total height, but all these are slender, tapering sticks compared to the massive columnar Kauri. The biggest Karri I could hear of in Western Australia yielded 3,750 c. ft. of log timber (Properjohn). This is under one-eighth the timber of the record Kauri tree called "Kairaru." The largest Karri (*Eucalyptus diversicolor*) I was able to see during a week's stay in the heart of the best Karri forest was 11 ft. log-diameter by 270 ft. total height. The 11 ft. of diameter represented the base of the log, excluding the great bulge above the root. The recorded diameters of most of the big Australian or American trees mean very little as regards the size of the log of timber furnished by the tree. That is well shown at page 48, where one of the big Australian trees is being taped. In my measurements of the Australian trees I found the diameter of the log, taken above the root-bulge, was generally a good deal less, often only half, of what is commonly entered as the base of the tree.

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* Mr. W. B. Buckhurst, Crown Lands Ranger, Christchurch, knew "Kairaru" well by repute, in the old days. He has even seen a photo of it. He tells me it grew at the base of the Tutamoe Range, on clay soil. There is still Kauri in the Tutamoe Forest, one of the Kauri forests that most urgently needs demarcation and redemption. (*Vide* "Waipoua Kauri Forest," p. 51.) The discovery of "Kairaru" by Mr. Percy Smith late Surveyor-General, is described in a note at page 189.

The best account of the big Eucalypts of Australia is that by Dr.[*] J. H. Maiden, the Government Botanist of New South Wales, published in the *Sydney Morning Herald*, and in the *Indian Forester*, 1904. It tells how exaggerated are some of the accounts published of the giant Gums of Australia, with heights taken perhaps with two bits of sticks, or with girths taken on the ground or a foot or two above it! Such a girth speaks more about the roots than about the true basal diameter of the shaft of timber.

Mr. Stanley Dobson, who spent much time trying to get at the truth in regard to these big trees, writing to the Royal Society of Tasmania, believed that the highest Eucalypt found by a Government Surveyor was near Neerim, in Gippsland, and was 325 ft. total height. It had a diameter of 18 ft. at 6 ft. above the ground. Two other giant Gums of about the same height are quoted. These trees are Mountain-ash (*Eucalyptus regnans*). In 1886 Mr. Perrin, then Conservator of Forests, Tasmania, gave detailed measurements of a fallen tree that he measured near Geeveston (*Euc. globulus*) that had 250 ft. of clean bole and a total height (estimated) of 330 ft. At 8 ft. above the ground the diameter was about 13 ft.

In New South Wales the biggest Eucalypt I measured was a *Euc. saligna* (locally "Blue-gum") 7 ft. 3 in. diameter and 285 ft. high. In Western Australia the largest authentic Karri trees I heard of were 12 ft. in diameter and 300 ft. total height. The largest I measured was 11 ft. in diameter, 93 ft. bole, and 270 ft. total height. This I called "The Western Monarch" because it was the same diameter as the champion largest Podocarpus tree in South Africa, known as "The Eastern Monarch." There is the evidence of a photo I have seen that "King Karri," the reputed largest Karri ever known in Westralia, was 372 ft. high. "King Karri" eventually blew down, and when cut up yielded 3,000 c. ft. of sawn timber. In the round the log was cubed at 4,500 cubic feet.

My practice in measuring basal diameters is to take at 5 ft. above the ground the diameter of the shaft of timber as estimated by eye. This leaves the basal bulge out of account, but, of course, includes the real taper and shape of the shaft of timber. It is the dimension that would be used in measuring the timber-content.

Eucalyptus jacksonii ("Red Tingle-tingle") is a new species of Eucalypt in Western Australia *reputed* to be even taller than Karri and to attain a height of some 400 ft. It is confined, says the Conservator (Mr. Lane Poole), to a small area some six miles by fifteen miles along the Franklin River, about forty miles to the west of Albany.

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[*] Courtesy title employed at the meeting of the British Association in 1914 at Sydney (*vide* address of President of the Botanical Section). I use the designation "Dr. Maiden" here in order to avoid having repeatedly to explain that he represents by general consent the premier botanical authority in Australia. Being an F.R.S. it matters little whether his doctor's degree is academical or *pour le mérite*.

CALIFORNIAN GIANT TREES.

"Big Tree," or Wellingtonia.—Exaggerated basal measurements are often recorded for the Californian "Big trees." Says U.S.A. Bulletin 95, "Commercial Woods of the U.S.A.," speaking of the Californian Big tree *Sequoia gigantea*, "Mature trees attain heights of from 200 ft. to 350 ft. and diameters of more than 25 ft. Including the great swelled bases, specimens have been measured nearly or quite 40 ft. in diameter." The largest authentic diameter for a Wellingtonia (*Sequoia gigantea*), clear of the root-bulge, is 27 ft. (Elliott, 1912, "Important Trees of the U.S.A.") Sudworth in "Forest Trees of the Pacific Slope" quotes 27 ft. as the maximum diameter, and adds, "The height and diameter of the trees is popularly much overestimated." Deducting one-twelfth of the diameter for the very thick bark, there is thus little difference between the real basal diameter of the Californian "Big tree" and the New Zealand Kauri. It seems possible that before the advent of the Maoris or their predecessors, with their bush-fires, the log basal diameters of the giant Kauri trees of those days may also have been the largest in the world. As is well known, the mound of resin-soaked bark ("bukau") at the base of all old Kauris and their naked live bark make them peculiarly susceptible to fire, while the thick-barked Wellingtonias are fire-resistant. Thus, without going into figures, there is a strong presumptive case of Kauri being the biggest timber-tree in the world. The basal diameter of its bole is little less than the Californian "Big tree," the height of its bole is not greatly less, while the "form-factor" (representing the shape of the bole) is about 95 for the old Kauri trees and about 45 or 55 for the Californian "Big trees," a cylinder being 100. Happily, however, exact figures of the comparative timber-yields of the two trees are available.

In Professor Sargent's great work, "Silva of North America," it is stated that the tallest living Sequoia that has been measured was found to be 325 ft. high: it is one of the "Three Sisters" standing in the Calaveras Groves; the other two also exceeding 300 ft. in height.

In 1912 an Act of Congress was passed securing for the nation the Calaveras Groves. A previous Act for the same purpose, passed five years earlier, had proved inoperative. When the Government was considering the acquisition of the two Calaveras Groves the Sequoia trees in the groves were counted and measured. The measuring was done by the United States Forest Service, and the method followed is detailed in an official bulletin, No. 397, "Calaveras Big Tree National Forest." The area of the two groves is 491 acres. The twenty largest trees contained an average of 21,386 sup. ft. each of merchantable timber, or one-tenth of the giant Kauri, with 213,333 board feet.

> The largest fallen tree in South Grove is "Old Goliath," which has a gross volume of 127,892 board feet. The largest at North Grove is "Father of the Forest," and through its hollow trunk one may ride horseback. The largest standing tree in South Grove is "Louis Agassiz," which before being hollowed by fires probably had a gross volume of 124,163 board feet. In North Grove the "Mother of the Forest" probably had a gross volume of 140,619 ft. It is dead, but standing. The taper of the big trees varies from 3 in. to 12 in. for a 12 ft. log, and will average between 6 in. and 7 in. The maximum thickness of the bark is 24 in. . . . the thickness of bark will average one-twelfth of the outside diameter. (Calaveras Big Tree Bull. of 1912.)

The largest of the "Big trees," "Mother of the Forest," with a gross volume of *140,619* board feet, may be compared with the largest Kauri in the Tutamoe Forest, which, as below, had a quarter-girth volume of

295,788 board feet of sawable timber. In other words, the largest "Big tree" of California contained less than half the timber of the largest big Kauri of New Zealand. Good pictures of the Californian "Big trees" are given in Professor Huntington's remarkable pamphlet "The Secret of the Big Trees" (Superintendent of Documents, Washington D.C.).

Redwood of California.—According to measurements taken by the U.S.A. Forest Service, Redwood is actually the tallest tree on the North American Continent, 350 ft., but it is of a comparatively slender, tapering form, and is far from carrying the massive timber trunk of either the "Big tree" (Wellingtonia) or the New Zealand Kauri. Diameters up to 20 ft. have been measured above the much-swollen base, with 100 ft. of bole. ("Commercial Woods," U.S.A. Bull. 1911.) These are about the dimensions of the record Kauri trees, so that the difference between the Redwood and the Kauri lies solely in the bark-thickness of 3 ft. or 4 ft. on to the diameter, and in the tapering form of the Redwood as compared with the cylindrical form of the Kauri.

Douglas-fir.—The third largest timber-tree may be Douglas-fir, for which over 8,000 c. ft. has been recorded, or rather more than one-third the size of the record big Kauri tree of New Zealand. In that fine classic, "Forest Trees of the Pacific Slope"—of which there ought to be thousands of copies in New Zealand—Sudworth says definitely that Douglas-fir is the most gigantic tree after the great Sequoias of California. Maximum dimensions are 8 ft. or 10 ft. in diameter and over 200 ft. high. He adds: "The Douglas-fir furnishes the finest and largest saw timber of any native tree, if not of any trees in the world." What would he say to Kauri, with the timber unquestionably superior to Douglas-fir (Oregon), and with maximum diameters double those of Douglas-fir?

Professor K. W. Woodward, in an article on "Tree-growth and Climate in the United States" (Journ. For., Washington, May, 1917), considers that Douglas-fir should be classed as the tallest of American trees; and he quotes a tree 23 ft. in diameter at the base; 161 ft. to the first limb, where the diameter is 11·5 ft.; the total height of the tree being estimated at 300 ft. Here again the dimensions are somewhat above those of the giant Kauris, but the taper makes it cube less.

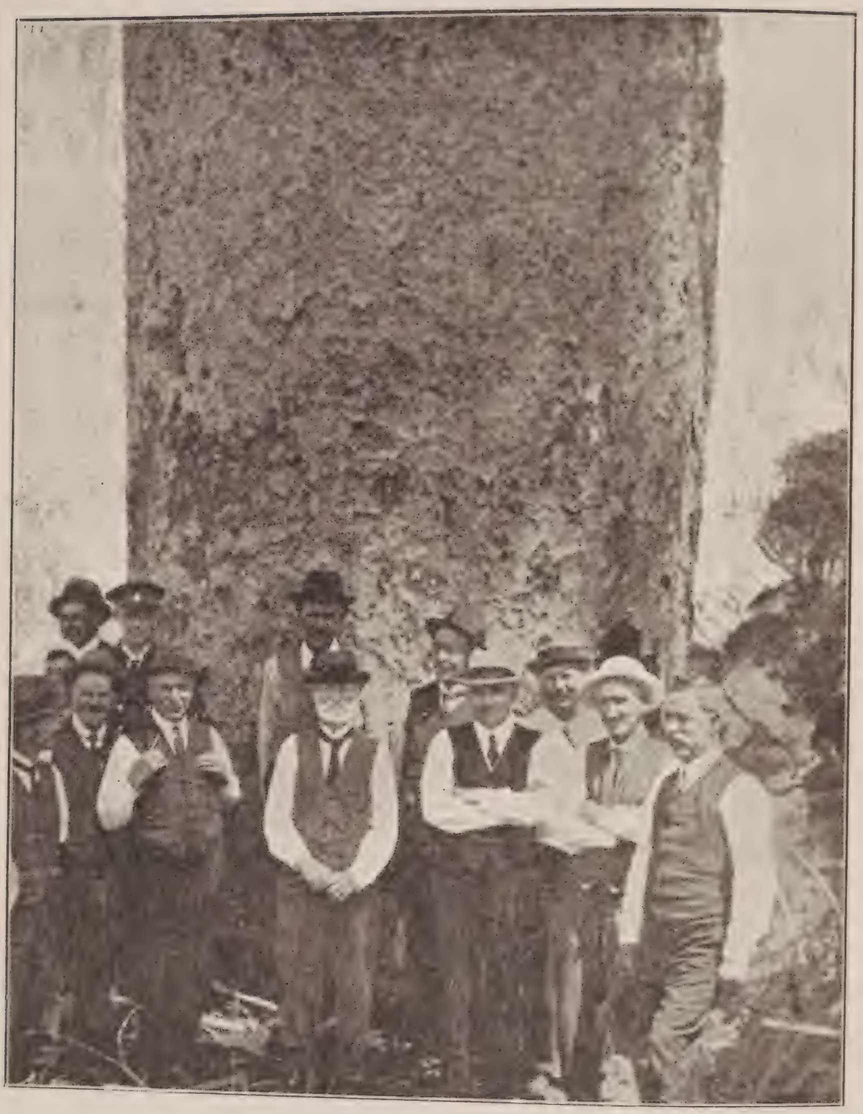
Pinus lambertiana.—This, the largest pine in the world, is a taller tree and has a longer bole than the Kauri, but accounts differ as to its maximum diameter. Sudworth speaks of diameters up to 7 ft. ("Forest Trees of the Pacific Slope"), but "Commercial Woods of U.S.A." speaks of reports of trees 20 ft. in diameter, including the thick bark. Like the Kauri, it has a bole with little taper. Kent, in Veitch's Manual, described it as 10–15 ft. in diameter. Sir J. D. Hooker describes it as "wanting the bulk in proportion to height of a Sequoia." There is, I think, no question as to the giant Sequoias containing a greater bulk of timber than Sugar-pine: and thus leaving the Kauri with easily the largest bulk of timber.

OTHER GIANT TREES.

There are other gigantic trees larger in one dimension than Kauri, but all yielding less bulk of timber.

Australian Red Cedar.—The Australian Red Cedar (*Cedrela australis*) is frequently quoted for its great diameter and big yields of timber. Von Mueller, the Victorian botanist, and not a very reliable authority,

PLATE VIII.



A TAPERLESS KAURI AT NIHOTUPU, AUCKLAND CITY WATER-AREA.

Mayor and Council at base of the tree.

Auckland Weekly News, 13th November, 1918.]

[*To face p. 47.*

mentions a tree which at 10 ft. above the ground was 16 ft. in diameter and gave 76,800 sup. ft. of sawn timber. Wools, a quite reliable authority, cites a tree yielding 28,800 sup. ft. The biggest timber-yield of any Cedar tree cut on the Bellinger River of New South Wales was 3,666 c. ft., or 43,992 sup. ft. It is probable that no Australian Cedar has yielded more than 48,000 sup. ft. of sawn timber; and only very few trees were a little larger than 10 ft. diameter and 200 ft. high. (Maiden.)

As mentioned above, a tree that in all forests of the New Zealand class most recalls the Kauri is the Outeniqua Yellow-wood of South Africa (*Podocarpus elongata*). It gives the characteristic appearance to the South African coast forest in the latitude of northern New Zealand, making that forest so like a Kauri forest in general appearance that a photo of one would do for a photo of the other. The giant Yellow-wood of South Africa is about two-thirds the maximum height, and the maximum diameter is exactly one-half of that of the largest Kauri trees, so that its bulk of timber would work out to less than one-fourth of the biggest Kauri trees of New Zealand.

In equatorial Africa I have seen huge trees, as trees go in Europe, but they had tapering stems of the usual form, and would not yield a volume of timber comparable to Kauri. One tree, the so-called "Pillar-wood," in the fine forest on the eastern side of snowy Mount Kenia, had a form like Kauri, but I cannot recall diameters over 8 ft. or 10 ft.

The tropical Baobab (*Adansonia digitata*) and the Chestnut trees of Mount Etna may have a basal diameter equal to New Zealand Kauri, but there all resemblance ceases. They have little height, and are far from presenting the almost cylindrical shafts of timber seen in the Kauri. The Baobab has diameters up to 30 ft., and the Australian form nearly the same. A good drawing of this grotesque tree is given in a common useful little work, "Lindley and Moore's Treasury of Botany." The Baobab is in no sense a timber-tree. Its shape is more that of a huge carrot. In parts of Africa the Natives hollow out the tops of the trunks to store water. The text-books, however, usually claim it as a giant tree.

The biggest timber-tree I have heard of in England was an Oak in south Wales, with a volume of 3,032 c. ft. (Hanson). It was thus about one-eighth the size of the record Kauri tree of New Zealand. This English Oak sold for £105 as it stood, and cut up yielded £500 worth of timber. The record big Oak from the Forest of Dean, so famous for its Oaks, was rather smaller. All the very old Oaks in Europe are hollow shells. Even if sound they would not come near the giant Kauris either in age or timber.

THE TAPERLESS KAURI.

No less an observer than Charles Darwin was the first to place on record the remarkable shape of the Kauri tree. The mature Kauri trunk is columnar; it shows very little taper. That, combined with its large size, is why it cubes out so high. (Plate VIII.)

When I was in Auckland Mr. Trounson kindly gave me a large-size photo of the biggest Kauri known to him. The tree was 17 ft. in diameter, and the photo was shown at the recent Auckland Exhibition. I have scaled the taper on the photo of this tree. If the photo has any distortion it will tend to make the upper part of the trunk smaller. But the photo shows 47 mm. at the base and 45 mm. at the crown end of the bole, omitting at each end the bulge projecting from the parallel sides of the log, as that would be squared off. This bulge is greater below the great spreading crown than near the ground, as is usually the case with big old Kauris, resulting in a reduction of the taper to little or nothing. Mr. Trounson's giant tree measures on the photo 140 mm. in length of bole, so that the taper is here 2 mm. in 140, or 1·4 ft. of diameter in 100 ft. of length.

The small Kauri figured on the 1914 Panama Exhibition pamphlet shows the form of the Kauri trunk particularly well. Omitting the small basal bulge the thickest part is below the crown.

In the New Zealand Official Year-book for 1899 is an account of New Zealand forestry, and a figure of a fairly large Kauri tree, 15 ft. 4 in. in diameter and 46 ft. bole. This is the same size above the basal bulge as below the branches. Taking the lines of the bole generally, there is a taper of 2 ft. diameter per 100 ft. of length. There is usually less. I have scaled the trunks in a collection of photos of big Kauri trees sent me from Auckland. Allowing a small amount for photographic distortion, the diameter of the boles below the bulge where limbs go off is practically the same as the diameter above the bulge of the root; but the lines of the bole do not go up quite straight—there is a slight hollowing or bending inwards at the centre of the bole.

In the Lands Department yearly report for 1905, p. 76, is one of Mrs. Grace Matthews's beautiful photos, showing a smallish Kauri tree 9 ft. diameter by some 40 ft. bole. This tree above the basal bulge is distinctly smaller in diameter than below the crown bulge.

When in the Waipoua Forest I cubed some of the timbermen's estimates of the quantity of sawn timber that could be got out of various Kauri trees, and found that their estimates corresponded pretty closely with "form-factor" = 1·00.

The Hon. Pember Reeves gives a good popular description of the remarkable timber-producing form of the Kauri tree: "As the British ox, with his short horns and cube-like form, is the result of generations of breeding with a single eye to meat, so that huge candelabrum the Kauri might be fancied to be the outcome of thousands of years of experiment in producing the perfection of a timber-tree. Its solid column may rise 100 ft. without a branch; it is all timber—good wood. Clean, soft, easily worked, the saws seem to cut it like cheese." ("The Long White Cloud," p. 321.)

Timber Measurement of Kauri and a Giant Eucalypt.

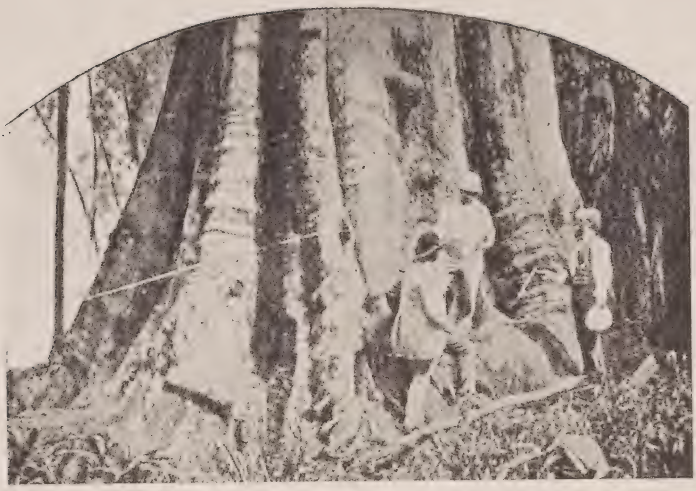
The two cuttings (Plate IX), taken (1) from the last number (March, 1917) of the Australian Forest League journal (Victoria), and (2) enlarged from the letter-paper of an Auckland Kauri-gum merchant, show how the volume of Kauri timber can be easily calculated from the girth and length of bole, while for the Australian and Californian big trees this would be difficult to do on account of the irregular swollen base and rapid taper of the trunk.

Cubic Contents of the Record Big Kauri Tree.

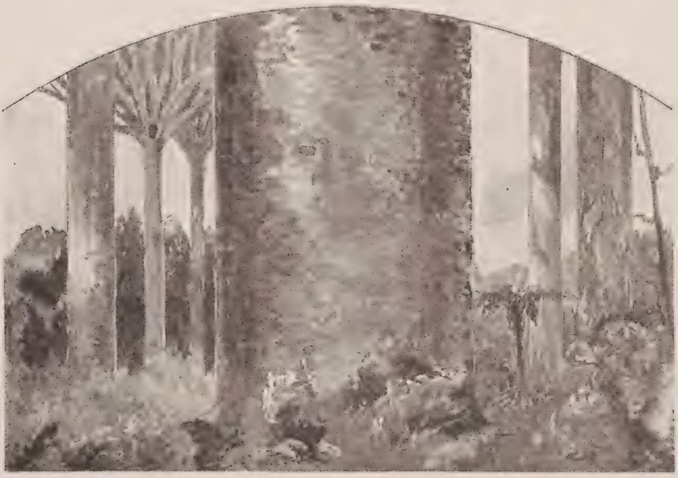
The bulk of timber in the record big tree of the Tutamoe Forest, called "Kairaru" by the Maoris, works out thus :—

There is little or no taper. Kauri sheds its dead bark in scales, and the live inner bark is rarely more than 2 in. thick. In old trees the heap of bark debris, sometimes 6 ft. or 8 ft. high, called "bukau," gives little chance of much of the basal bulge, small as it is, getting measured in. The observer stands above it.

PLATE IX



Measuring the swollen base of a great Gum tree (*Eucalyptus regnans*).



Little or no swelling at the base of Kauri trees.

[*To face p. 48.*

Cubic Content of "Kairaru."—To allow (1) for bark, (2) a slight taper or hollowing of the bole about the middle, and (3) the chance of just a little of the basal bulge being measured in, I will take 20 ft. as the average diameter of the Tutamoe giant tree, instead of 22 ft. The cubage then works out as follows :—

Full volume ($\pi r^2 \times$ bole-length) :—

$3{\cdot}14159 \times 10^2 \times 100$ ft. = 31,416 c. ft., or 376,992 sup. ft. in the log.

Quarter-girth :—

$$\frac{(20 \times 3{\cdot}14)^2}{4} \times 100 = 24{,}649 \text{ c. ft., or } 295{,}788 \text{ sup. ft. in the log.}$$

For comparison I will take a log rule used in nine of the States of the United States of America—viz., $\frac{2}{3}$ diameter squared × height : then one has $(20 \times \frac{2}{3})^2 \times 100 = 17{,}778$ c. ft., or 213,333 sup. ft. This gives sawn timber.

In round numbers one may say that "Kairaru," if sound, carried $\frac{1}{3}$ million sup. ft. of merchantable timber in its bole and branches.

Its gross cubic content, 31,416 c. ft., is nearly seven times the size of "King Karri," 4,500 c. ft., the record big Karri tree (*Euc. diversicolor*) of Western Australia (p. 44).

Value of "Kairaru."—Present selling-rates in New Zealand are on quarter-girth measurement, and the market royalty 1s. per c. ft. (8s. 4d. per 100 ft. sup.), so that the present-day royalty value of the giant tree would be 24,694 c. ft. q.g. at 1s. = £1,235.

There is a Greek proverb which says that any man planting a Cypress tree plants a dower for his granddaughter, so valuable is Cypress timber. Any old-time New Zealand settler rescuing a giant Kauri tree from the holocaust of those days would have provided a dowry for his granddaughter worth something near £1,000 at present-day prices for Kauri timber.

Kauri the Most Massive Timber-tree in the World.

Various observers have compared the shafts of Kauri timber to the columns of a Gothic cathedral. The comparison is apt. I have seen most of the cathedrals of Europe, and quite recently those of Spain. The quality that at once arrests attention in the giant Kauri trees is their massiveness. It is this quality which compels comparison with the shafts of masonry in these old cathedrals, the grandest of man's buildings. Massiveness is the pre-eminent quality of the giant Kauri trees. They are not very tall trees as giant trees go, but the straight shaft of timber with its perpendicular lines is rarely seen in other trees. I know only one tree quite like it. That was, as mentioned, in a forest of huge timber on the eastern side of Mount Kenia, in equatorial Africa. This tree had lines as perpendicular as the New Zealand Kauri, but it was not above one-half or two-fifths the size of the New Zealand Kauri.

It is doubtful if there are finer trees in any tropical forest than that on the Western Ghats of India. Captain Campbell-Walker was familiar with these. Nevertheless, on seeing the Kauri forests of New Zealand he wrote, "On my first view of Kauri forest I was much struck by the colossal dimensions of this noble tree." He had only a comparatively short time in the Kauri forests, and apparently the size of the largest Kauri tree he saw was 10 ft. diameter—about one-quarter the size of the record big trees.

Dr. Hochstetter, in his book on New Zealand, written in 1867, comments on the columnar appearance of the Kauri trees. He adds, "The eye follows unimpeded to where the powerful branches are twined into a dense dark-green roof, through which, like golden stars on the roof of a vault, the light of day peers into the dusk of the forest."

KAURI PARK AND CALAVERAS.

Trounson's Kauri Park ("Waipoua Kauri Forest," p. 52) is the Calaveras Groves of New Zealand. There is still hesitation about acquiring it: this is only natural until the usual means of taking care of it—a Forest Department—is brought into existence. In the hope that both may be soon achieved I append an extract from the official letter to the Senate of the United States of America recommending the acquisition of the Calaveras Groves:—

> I cannot express too strongly my feeling that these great national wonders, famed throughout the world, should become the property of the nation and be protected from intentional or accidental destruction as far as possible. It has taken thousands of years to produce many of these trees, and if once they were destroyed no skill or expense could bring similar wonders of creation into existence within a time represented by the known history of the world.

The Calaveras Groves were acquired by an exchange of land plus £2,000 for expenses.

Since the above was written Mr. Trounson's princely gift to the nation of Kauri Park has been announced. It is about 60 acres in area, and the timber is valued at upwards of £10,000, or at the rate of £166 per acre. The Forest Department has not yet begun to be organized, so that herein lies a danger. Kauri Park may be burnt.

AGE OF THE GIANT KAURIS.

If the Mercury Bay tree, 24 ft. diameter (= 12 ft. radius), be divided into three periods of 8 ft. its age might average out as follows:—

				Years.
8 ft. diameter, or 48 in. radius, at	10	rings per 1 in.		480
,, ,,	15	,,		720
,, ,,	25	,,		1,200
				2,400

Kirk's estimate of the age of this tree was "considerably over four thousand years"—on the face of it an excessive estimate. This is the Kauri tree with the greatest diameter on record, but as its height to the first branch was 80 ft. and "Kairaru" was 100 ft. the latter cubes larger.

Kauri grows so rapidly for some 400 or 500 years that, omitting the dominated heart, which is an accident of position, the outer rings for many centuries may be as broad as the inner ones, but after that the common rule must hold and the rings get narrower. They must get narrower for two reasons: (1) Each year's carbon-fixation has to be spread over an ever-lengthening periphery; (2) as a tree gets old and its vitality decreases it gets thin in the crown and assimilates less. All very old trees have very thin yearly rings.

Thus, so far as one can judge from estimates, 2,400 years may be the age of the oldest New Zealand Kauri tree. But there is still room to hope that exact figures obtained from counting the rings may be obtained. The Mercury Bay tree-stump may be still in existence, and even the heartwood part of the stumps of some of the other old giant trees, possibly even the stumps of Kairaru or of Nga-mahangahua, the other giant tree of the Tutamoe Forest. (Kirk's "Forest Flora," p. 144.)

In age the New Zealand giant Kauris are probably not the equals of the big trees of California. Says "Uses of Commercial Woods, U.S.A.," p. 59:—

> In one instance a tree of 24 ft. in diameter was less than 1,300 years old. Another of similar size showed more than 4,000 rings, but they were so intricately involved that he (the computer) was unable to satisfy himself that he had counted all of them. It is believed that no tree of this species showing more rings than 4,000 has been placed on authentic record. . . . The Forest Service has made accurate measurement and record of every ring of growth in a tree more than 34 ft. in diameter [including basal bulge and 3 ft. or 4 ft. of bark.—D.E.H.], and it is shown that during certain periods of years the tree grew three or four times as rapidly as during other periods. It is further shown that the times of rapid growth and of slow growth were not dependent upon the size or age of the tree, but occurred at different times during the tree's history, suggesting that successive changes in environment produced changes in the rate of growth, and accounting for the fact that while one tree 24 ft. in diameter might be 1,300 years old, another of similar size might be 4,000.

Professor Huntington took his record back to 3,400 years.*

Mr. Cheeseman showed that Kirk's estimate of the age of Kauri trees was excessive. He might have added that Humboldt's estimate of the age of the giant Dragon tree of Orotavo was equally a guess, and is not accepted by scientific men in Orotavo. I studied this tree when visiting Orotavo a few years ago.

Work to be done on Kauri Rings.

It seems, from p. 144, "Forest Flora," that Kirk was not familiar with the rings of growth on Kauri tree-sections. On the large number of Kauri rings that I have now seen there is no appearance of secondary rings, or indication of Kauri rings being other than yearly. White-pine does sometimes show secondary rings, and Honeysuckle (*Knightia*) has no yearly rings, but Kauri rings are generally quite clear, easy to count, and certainly yearly. Mr. Cheeseman's examination of the rings on the young trees of known age in the Auckland Domain showed that they were yearly in every case.

In New Zealand, with all the solid scientific work that has been done in many directions, the rings on these old-time Kauris have not been counted and analysed as has been done with trees of similar age in America. Kauri rings might throw light on many points of old New Zealand history—cycles of drought or rain, volcanic eruptions, possibly the coming of the Maoris or their predecessors with bush-fires. Some most interesting results from this work have been published recently in America.* The study in Kauri stumps at Kauri Park (p. 12) shows various suggestive groups and phases in the growth.

It is significant that the giant Californian tree and the giant Kauri are found growing in exactly the same latitude on different sides of the Equator, which is nearly the calculated maximum of summer insolation.

Largest Existing Kauri Trees.

The largest *existing* Kauri tree is unknown. As long as their destruction continues unchecked there is not much interest in trying to find out, for what is the largest tree to-day may be gone to-morrow. I have heard of several exceptionally large Kauri trees, but further inquiry has shown either that the size of the tree had been exaggerated or that it had vanished! Mr. Carroll, of Kaipara, told me in 1915 that the largest sound Kauri he knew was 11 ft. diameter and 56 ft. bole; the largest hollow tree 22 ft. diameter and 60 ft. bole. The greatest length of bole he has known is 120 ft. One of the finest of the unique group of Kauris (Stonehenge, "Waipoua Kauri Forest," p. 51) was burnt shortly before my visit: the big tree of the Auckland Exhibition (see p. 48) has since been burnt. I heard of a particularly large Kauri near Auckland which was purchased as a national monument by a former Governor, the late Lord Glasgow. It was destroyed shortly after he left!

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* "Secret of the Big Trees," by Professor Huntington, of Yale University (Government Printing Office, Washington. Price, 2½d.)

That it is not intended, in an orderly British community, to allow a tree of world-wide interest to perish from the face of the earth is shown by the large expenditure on forestry—totalling well over half a million—and on the scenic reserves, some £90,000; but the means taken have not been those of other countries, and it cannot be contended that the results produced are the best attainable. Australia spent many wasted years over Forestry Boards and make-believe Forest Departments, always looking back on the Old Country, where there is no State forestry, and forward with the crude idea that "wool is better than wood" up to any point. Australia before the war was paying some three millions and a half yearly for imported timber; and Australia has lost a great industry, some of the best of its population, and the splendid hardwood market which opened up in Europe when Oak-growing became unprofitable. Australia has a timber use now reduced to 23 c. ft. per head, against 230 c. ft. per head in America for both timber and firewood.

It may be added that New Zealand, with its reckless forest-destruction, is now on the verge of a wood famine, with a timber-consumption reduced to 25 c. ft. per head. House-building is approaching famine prices; firewood has reached it; while the rise in the cost of living is often put down to irrelevant issues. Sheep and cattle (not required for milk) graze near the centres of population, *while timber and firewood rot unutilizable on distant mountains.*

THE KAURI TREE WILL NOT BE EXTERMINATED.

Nevertheless there is a bright side to this sad picture of isolation, backwardness, and national loss. The shoe is pinching, and the people will not much longer tolerate being deprived of one of the prime necessaries of civilized existence—timber and firewood. When New Zealand does see better days, with the forestry and Forest Departments of other countries, there will be still left enough Kauri trees to show, in a comparatively short time, what the old-time, world-famed, giant trees were like. For Kauri is still growing fast and strong when most trees are in decrepitude, growing slowly and weakly. Of large trees up to 15 ft. in diameter there are a fair number left, both in Government forests and in the larger area of alienated forest, which may yet in great part be redeemed and saved to the country. Such trees as that shown in the botanical report of Waipoua by Dr. Cockayne will be preserved, we may hope, with the Waipoua Forest. It is certain that once the present fatuous forest policy is shaken off, monumental Kauri trees will be preserved religiously, as France is doing to-day with every scrap of national forest left to the country after the excesses of the French Revolution and the corrupt government of Napoleon III. And, it may be added, France is doing more: before the war, each year's Budget had an item of one million francs for forest redemption!

Tourists alone would make it worth while to preserve the giant Kauri trees left to New Zealand, apart from the fact that the growth of the national spirit stimulated by this war, and the return of the Anzacs, will insist on the preservation of these unique and world-famed monuments of old New Zealand. In Europe, only England and the Balkan States are, as regards forestry, in the position of New Zealand; and the Balkan States are not destroying demarcatable forest like New Zealand is. Their forest is inaccessible. Turkey even has a better forest policy than New Zealand, though in truth it is not carried out. Great Britain is paying a heavy penalty—forty-three millions yearly, in peace-times—for imported timber and the loss of the pick of its manhood. What forestry means to the best parts of industrial Europe—the Rhine Valley, for instance—can, as mentioned, be easily seen by studying the large-scale war-maps attached to this report (p. 188), and of which there are copies at the clubs and larger stationers' shops.

Like some other things of which New Zealand has the best in the world, it may be said judicially that the Dominion has probably the most valuable timber-tree. I have long been in the habit of assigning that place to Californian Redwood, which, amongst its many good qualities, has had a well-authenticated stand of timber going up to the extraordinary figure of one million board feet per acre. (Elliott, "Important Timber Trees, U.S.A.") That was when I had only a book knowledge of Kauri. Now, when I consider the majestic growth of Kauri on a soil too poor, and in a climate too wet, to produce anything else approaching its value; when I see the size of Kauri, its breadth and height approaching those of the largest trees known, and its yield of sawable timber double; when I reflect on the soundness and good shape of Kauri giving the minimum of waste in working it up; and the all-round value of Kauri timber, in this respect so much like Teak; I am forced to conclude that though silviculturally Californian Redwood has qualities not possessed by Kauri, it is certain that Kauri ranks with Oak, Teak, Mahogany, Red Cedar, and some half-dozen others of the world's best timbers, while at the same time it gives about double the timber per tree of any of them.

The Press of Christchurch of 17th April, 1918, had cable news—"Sir William Schlich is amazed that nothing is done to restore the Kauri, one of the finest coniferous timbers in the world, beyond the reservation of a few acres for sentimental purposes."

ECONOMIC USE OF KAURI LAND.

The "gum" lands north of Auckland even in this time of inflated land-values are only valued at about £1 per acre. Thus vanishes here the first difficulty of forestry in New Zealand—high land-values.

The Kauri-gum Commission of 1898 said,—

> Generally speaking, the good land is in the valleys and is of comparatively small extent: 5,000 acres here, then a stretch of perhaps 10 miles of poor pipeclay gum land; next 6,000 acres of fair settlement lands, and again a stretch of 15 miles of pipeclay lands, and so on. . . . There are stretches of gum land everywhere throughout the north, where repeated burnings have caused every vestige of soil to disappear.

The "gum" in the ground shows that this was once Kauri forest. To reproduce the Kauri forest by the agency of Manuka, as a soil-restorer and shelter-provider, should be the same national work to New Zealand that the French put in hand when they started replanting their ruined alpine forests.

So poor is this Kauri "gum" land now that the Commission actually recommended its being sown with gorse! The "gum-digging" offers a unique chance for the economical restoration of the Kauri forest (p. 118), and thus the perpetuation of the "gum" industry.

When in Auckland I had the advantage of meeting Mr. E. P. Dansey, an Indian forester (trained at Nancy, France), who has held an important position in the Indian Forest Service. He has spent two years in New Zealand, fishing and exploring in the North Island. His opinion is that, with the exception of isolated valleys and patches, the great bulk of the Kauri area is stiff, poor clay whereon Kauri is the most productive crop. He considers that the best apples cannot be produced much north of Auckland, for climatic reasons, and this is exactly my experience.

I am acquainted with apples as produced in Tasmania, where I lived for nearly a year in an apple-orchard; with apples in South Africa, where I had an intimate acquaintance with Rhodes's fruit-farms; with apples on the highlands of India and in equatorial Africa. The Tasmanian apples are very good. The South African apples, in the latitude of Auckland, in the hands of skilled Californian fruitgrowing experts, and a dry Californian summer, are of fair quality. But apples on tropical highlands are only worth growing for local consumption. Thus, in the interior plateau country of south India, where no other apples were obtainable, they were sold for nearly their weight in silver! But in Tasmania it would be thought that such apples were not worth picking. In the wet Waipoua area, and most of the Kauri forests, it will be readily conceded that fruit, except for small local supplies, does not deserve serious consideration. Fruitgrowing on a commercial scale and a dryish climate are almost synonymous, taking the world through. I was shown even Quince bushes in the Marlborough Settlement that had not borne fruit for nine years!

J. C. Firth, in an article on "Forest Culture" read before the Auckland Institute, gives his experience that fern lands in the northern part of New Zealand, above the 37th parallel, are more suitable to the growth of conifers, the soil being too sour for trees, making great demand on the soils. (Trans. N.Z. Inst., 1874.) That was exactly my experience in South Africa during the twenty-three years that I was planting trees there. We made it a practice to plant conifers on poor sandy land, Gums and leaf-shedding trees on stronger soils.

Kauri Soil.—Kauri is commonly said to grow only on poor soil. There is no better Kauri than that from Tairuwa (on the east coast, rather south of Auckland), where the soil is very poor and rocky. This has yielded the very finest soft-carving Kauri. That it does grow so well on poor soil is the economic strength of Kauri as a wealth-producer in New Zealand. It seems, however, more correct to say that Kauri grows well on both poor and rich ground. I have discussed this point with Ranger Maxwell, whose experience of the Kauri bush runs into sixty years. His opinion is that, generally speaking, the tallest trees grow on poor soil, while Kauri shows the most vigorous growth on good soil. He instances a tree he logged with 90 ft. clean bole, and which was growing on poor soil.

At the residence of the Hon. E. Mitchelson, at Remuera, Auckland, are Kauri trees growing on good soil and on clay, side by side. The trees on clay show the better growth—at seven years from seed, 14 ft. high, and visibly making 2 ft. yearly shoots.

Nothing that has happened since has impugned the accuracy of Darwin's dictum. The Kauri remains still the most valuable permanent source of wealth in the North Island. What else is there that, over 1,000,000 acres or more, on the poorest pipeclay land, can give *a net return of £10 per acre per year and permanent settlement at the rate of one family per 75 acres?* And this, too, with a rainfall so heavy that the little fertility in the soil is promptly leached out as soon as the forest covert is taken off.

THE LESSON OF THE PUHIPUHI KAURI FOREST.

Puhipuhi is an ideal forest country—steep, mountainous, and broken. It consists of a plateau 1,100 ft. high, cut into by steep valleys dropping down to within a few hundred feet of sea-level. Here runs the Waiotu River, where timber was floated down in the old days; and here now runs the trunk railway from Whangarei to the north, an appreciable item of its freight cut off with the destruction of the forest, and its acrim of 100 cubic feet of Kauri timber per year, over 17,000 acres—viz., a production of 1,700,000 cubic feet of Kauri timber yearly!

Unless there is an immediate change of forest policy, the next three or four years will see the end of the Kauri forests, excepting a remnant which has been earmarked for slower destruction by the Railway Department. Precious though these two Railway forests are (one was bought back at what was considered a fancy price), there is no sign yet of their being worked and preserved as the rest of the cultivated world works and preserves Government forests of much less value.

The fine Mamaku Forest, near Rotorua, is also being worked and destroyed by the Railway Department, instead of being worked and preserved.* What the destruction of the remaining Kauri forests of New Zealand will mean, in adding to the very heavy burden of the war taxes, will best be seen by taking a concrete case.

By universal consent the Puhipuhi Forest is considered representative of the best of the old Kauri forests, so that more note was taken of the circumstances attending its destruction than would have been the case with an ordinary Kauri forest. It will be seen, however, in the discussion which follows, that I have taken the Puhipuhi Forest as being no more and no less than an average fully-stocked Kauri area, so that the figures worked out below are representative of any of the ordinary Kauri forests of the Dominion, so far as they are now fully stocked, or after they have been regenerated or put into order by foresters. It will be seen later that there is reasonable ground for the opinion that the cost of this war to New Zealand would have been paid for had the original Kauri forests of the Dominion been worked and preserved as are the forests now in most civilized countries, and that this could have been done with considerable gain in the amount of timber available for cutting, and some gain in permanent land-settlement; since all the waste of burnt or deteriorated Kauri timber would have been saved, and there would have been permanent employment on the land at the rate of one man per 75 or 100 acres.

J.B.T., a recent visitor to Trounson's Kauri Park (p. 50), and one who knew the Puhipuhi Forest well in its nearly virgin state twenty-five years ago, has given me an interesting comparison between the two Kauri forests. He says the Puhipuhi Forest showed a greater number of trees with a taller average height. This accords with so many other observers. They compare the clean taperless stems at Puhipuhi to a string of candles set side by side. J.B.T. thought the soil better than that of most Kauri forests, but this opinion lacks confirmation. He describes the Puhipuhi soil as a fertile red loam over ironstone boulders. I found the soil now varying from poor clay to hungry gravel. In the plantation area the soil is certainly of the poorest.

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* Since the above was in print remedial measures have been inaugurated. Presumably as soon as a Forest Department is organized these forests will be definitely saved.

One of the Puhipuhi trees had a diameter of 18 ft.; another with a diameter of 10 ft. yielded 25,000 sup. ft. of sawn timber. Speaking from memory, he would average the thickness of the Puhipuhi Kauri timber at 4 ft. 6 in. The longest log worked by Mr. F. Mander, M.P. (p. 57) was 90 ft. The thickest tree he felled was 14 ft. in diameter across the stump. Trees under 2 ft. in diameter were not reckoned as timber by the Government measurers and were not worked in those prodigal days. When I was at Puhipuhi recently I saw Kauri logs down to 10 in. diameter being cut in a little local mill. 14 ft. diameter was the largest Kauri at Puhipuhi known to Mr. Anderson, the forest official now at Puhipuhi.

I have been to Puhipuhi and heard the story of its destruction by fire as told by different people, but more especially by Mr. Anderson, the forest official on the spot who has charge of the replanting-work now in hand. (See also Mr. H. P. Kavanagh's evidence before the Forest Commission.) In 1887 about *one-third of the area, containing some 300 million superficial feet, was burnt.* This fire lasted for several weeks. (Trans. N.Z. Inst., 1892.) The forest was filled with "gum-diggers" whose interest it was to burn the forest in order to get at the "gum" in the ground. With the fatal *laissez-faire* forest policy of those days, no adequate precautions could possibly be taken to stop the "gum-diggers" burning the forest. Austrians would not have done this thing in their own country, where there is no timber nearly as valuable as Kauri: in New Zealand it did not matter! And so New Zealand lost its most valuable forest, and the most precious forest it can have till, say, a century's forestry has restored the forests to more than their old-time value. The destruction of the Puhipuhi Forest by fire would have been readily preventable; it looks as if the replanting of the burnt area, even with the comparatively inferior exotic timber-trees now being tried, will be slow and costly.

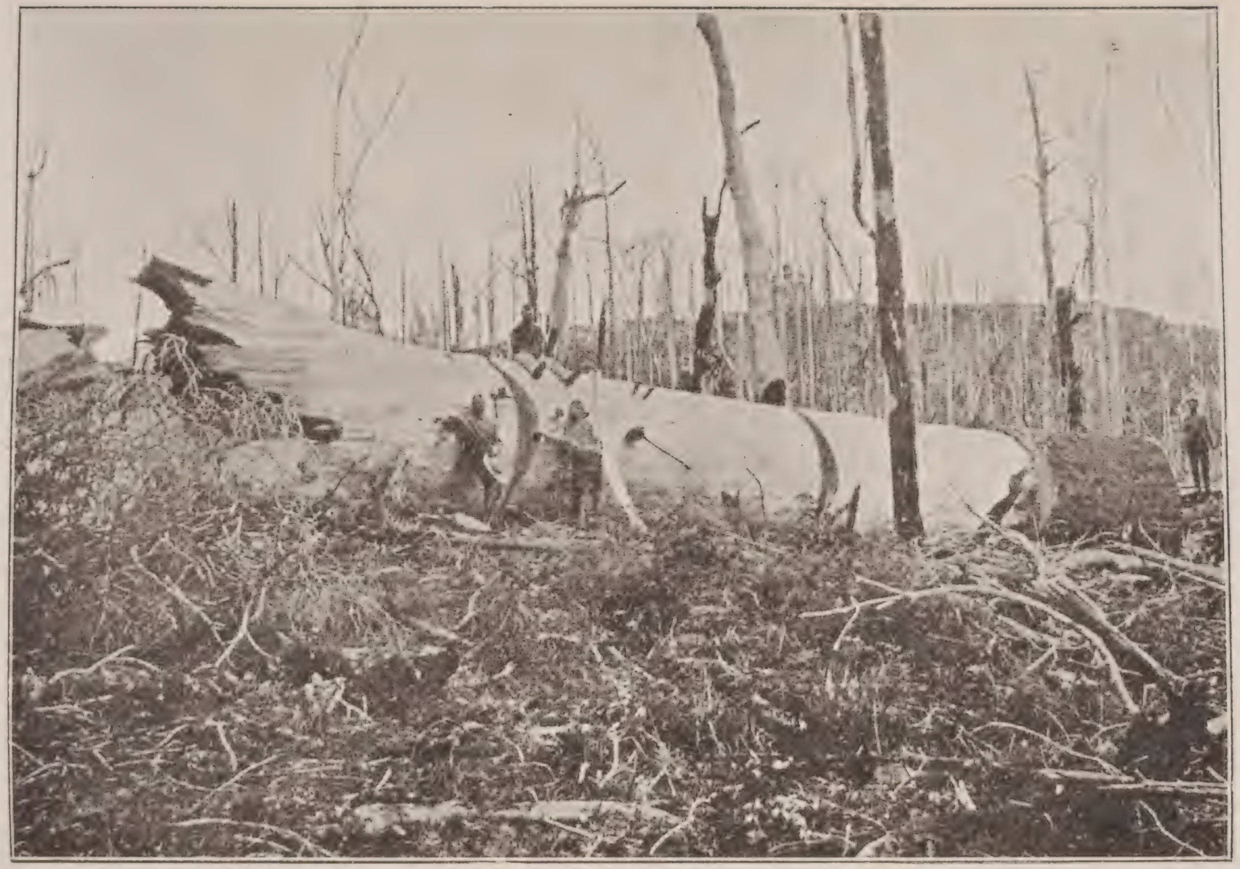
A responsible local Government official who knew the forest intimately has informed me that the destruction of the Puhipuhi Forest could have been easily prevented, but a selfish combination of local interests wanted it destroyed. This is another way of saying that if the forestry of the country is in a condition of anarchy people will make what they can out of national property left derelict.

Said the Hon. E. Mitchelson (Timber Commission Report, 1909, p. 585): A few years ago at Puhipuhi the Crown possessed one of the finest forests in New Zealand. It was a State forest specially protected. The bush was destroyed by fire and fully four-fifths of the timber absolutely lost.

Lost Value of the Puhipuhi Forest.

Timbermen, bush-workers, and others are agreed that the Puhipuhi Forest before its destruction by fire was, over one-third of its area at least, a continuous Kauri forest. Mr. Buckhurst saw it in 1874, and compares it with the once fine forest at Kaihu. The Puhipuhi Forest was then intact, untouched by fire. It was originally 17,000 acres: bought from the Maoris, and intended to be kept as a forest reserve. But no measures were taken to protect it from fire, or even to stop the "gum-diggers" setting it on fire. Then sawmillers, properly enough, were let in to work the burnt timber, but without supervision

PLATE X.



WORKING A BURNT KAURI LOG AT PUHIPUHI.

Photo, H. P. Kavanagh.] *[To face p. 57.*

and without the usual fire-protective measures, so that the advent of the millers brought more fires. Then silver-mines were discovered, and the scandalous mining-forest laws operated to hasten the destruction. There was a bad fire in 1881, but the burn that almost finished the forest, described below, occurred in 1887. In 1913, 11,900 acres of burnt forest was withdrawn from reservation. Old records speak of it as once the finest Kauri forest in New Zealand ("New Zealand Index," 1913). Says Mr. H. P. Kavanagh, writing to me recently, "Puhipuhi was a compact forest, easy of access by the public roads and well situated for economical working: hence its great commercial value compared with other Kauri forests."

The striking photo opposite (Plate X) of burnt Kauri logs and the burnt forest at Puhipuhi, by Mr. H. P. Kavanagh, is reproduced at p. 16 of the Lands Department, 1907, report on the timber industry. Other interesting photos of burnt forest and Kauri timber-working are given in the same publication.

As will be seen on pages 67 and 68 I calculate the net money loss in the destruction of the Puhipuhi forest at £3,972,115, taking the value of the virgin-forest timber at present Kauri prices, plus the capitalized value of future Kauri crops, less the value of the Kauri timber sold and of the present grass lands. £3,972,115 ÷ 5,667 acres = £701 per acre!

EMPLOYMENT: FORESTRY VERSUS GRASS.

Though the forest was so good the soil was mostly poor, and naturally became poorer with the loss of the forest covering. On the best of the soil dairying is in progress, with the result, from inquiries I made on the spot, that 200 acres give employment to one family and bring in about £1 per acre yearly in butter-fat, or 10s. net after deducting about 10s. per acre as the cost of labour. (For a discussion of these figures see p. 113.)

If the forest had been worked conservatively under trained foresters during the time that the crop of timber in the virgin forest was being cut, there would have been two or three times this amount of employment—in logging and milling the timber, in roading and in organizing the forest against fire, and in ensuring the full regeneration of the forest with the maximum Kauri crop.

Mr. F. Mander, M.P., who milled a considerable part of the Puhipuhi Forest, and some others, have informed me that it contained a large proportion of young timber. Thus the timber returns from the Puhipuhi Forest would have been continuous from the start of systematic working. There would have been little or no transition period. The forest by now would have been earning some £7 per acre per year net, taking the present market Kauri royalty at 10s. And Kauri timber is rising so rapidly in price that in a few years the Puhipuhi Forest would have been in the position of the normal Kauri forest and earning some £10 net per acre per year (p. 99). Full employment would then have been at the rate of about one man per 75 acres, as against one man per 200 acres under dairying.

MONEY RETURN.

The money-yield of dairying on this poor soil, impoverished by destroying the forest, is now estimated, as above, to average yearly barely £1 per acre gross, or 10s. per acre net. The yield of the normal Kauri forest, allowing only £1 11s. per acre for Kauri "gum," is estimated (p. 98) at a yearly average of £12 7s. 8d. gross (for timber, "gum," fungus, and all forest produce), or £10 16s. net. This is arrived at by taking Kauri royalty at 16s. 8d. per 100 ft. sup. q.g. (2s. per cubic foot*)—a fairly high figure, but a figure which it is believed Kauri will ultimately reach, since in the coming timber scarcity it is precisely timbers of the durable softwood class which will become most valuable—timbers such as Teak, Kauri, Cedar, and Mahogany. (This point is discussed at p. 105, but it may be mentioned here that 16s. 8d. per 100 ft. sup. has already been realized for Cedar in Queensland and for Stinkwood in South Africa.) Those who prefer to do so can estimate the future Kauri royalty at half this, and the revenue from the Kauri forest will still be high—viz., £7 17s. 8d. gross and £5 16s. net. ("Balance Statement," p. 98.) The lower figure is about the highest revenue from the most profitable of cultivated forests in Europe; but it must be remembered that such forests yield timber of a lower grade than Kauri—viz., perishable softwood—and that they are open to the competition of other forests at no great distance away. This is not the case in New Zealand. Whether the Kauri royalty be taken at 1s. or at 2s. the cubic foot—which are about the extreme limits—the revenue from a good Kauri forest such as Puhipuhi would be higher than that from all farm lands on such soil.

FAILURE OF PLANTING AT PUHIPUHI.

On what is described as the worst of the soil (1,200 acres being reserved for this purpose) unsuccessful attempts have been made to replant the Puhipuhi Forest, both with native trees and introduced trees. Mr. Matthews reported (Lands Department Report, 1903) "proposals for planting have been made to my superior officers." Some 400 acres of Totara—half a million trees (Forestry Commission, p. 12)—were planted. The Totara did not grow as it does in its native forest—in fact, it hardly grew at all: much of it died as it stood. It was then abandoned, and later shared the fate of the rest of the plantation in being burnt.

The failure of this one attempt to replant the native trees on any large scale was unfortunate. Totara is one of the native trees that best stands planting in the open. Any one of these four reasons would have been sufficient to account for the failure of the planting of the Totara trees here: (1) The destruction of the forest soil; (2) the planting of a shade-bearing tree in the open; (3) the exposed situation; (4) the rank growth of fern not combated with adequate mulching. The Totara might have stood one or even two of them: four was a good deal to ask of it. The failure was nearly complete, and fire finished it.

Similar attempts to plant the native trees in plantations have failed both in New Zealand and South Africa. But though these trees may fail when planted in the open, they can be preserved and multiplied

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* In this report, where I have had constantly to refer to both the short-measure British cubic foot used in New Zealand and the real cubic foot, it seemed best to write them differently, thus:—

A true cubic foot	c. ft.
The British quarter-girth or short-measure cubic foot unfortunately used in New Zealand (p. 75)	c. ft. q.g.
Superficial or board feet measuring 12 in. by 12 in. by 1 in. ..	sup. ft.

In New Zealand the millers' unit is 100 superficial feet = $8\frac{1}{3}$ cubic feet.
In America the millers' unit is 1,000 superficial feet = 83·3 cubic feet.

in the forest. We are always getting back to the point that the native forest should be conserved, as South Africa has for long conserved its similar forest.

Not much importance can be attached to the failure of the Totara and other planting at Puhipuhi. The attempt shows a praiseworthy endeavour to repair in a slight degree the great public loss in the burning of the forest, for which only the faulty national forest policy of the country was to blame. Though the New Zealand trees are more hardy than the South African, and Totara especially has often been planted successfully in the open in New Zealand, that is usually as a garden-tree under cultivation, or otherwise under conditions that approximate to its natural forest surroundings. The planted Totara trees at Puhipuhi were in an exposed situation; they were on a poor soil degraded by frequent burning, and leaching out under a heavy rainfall. Nor were the young trees mulched, which would have been the first condition of successful growth among the rank weeds that followed in the wake of the burnt forest. To destroy forest and attempt to replant it as was done at Puhipuhi brings at once two heavy burdens on the shoulders of the destroyer: (1) Loss of the forest soil, the product perhaps of centuries; (2) the interest charge which has to be debited against all forest plantations.

The yearly plantation reports (Lands Department) make pathetic reading. They leave the impression that outraged nature had determined that after one of its grandest works had been wantonly destroyed, finicking attempts at planting exotics were to be denied even a semblance of success! Only open-root transplants (the mossing is reported to have been harmful rather than otherwise) were used, and many of the exotics were so unfitted to the climate that they could not be expected to succeed—Douglas-fir, *Eucalyptus cladocalyx*, and *Euc. redunca*, for instance. The same report (1906–7) mentions a rainfall of 92 in., and adds naively, "*Euc. crebra* is also making slow growth." *Euc. crebra* is a dry-country tree growing naturally in a rainfall of 15 in. to 20 in., and poorly in heavier rainfalls. It has long been under cultivation in South Africa.

It is stated that the responsible forest officer at that time did not know one Eucalypt from another. He certainly, in his writings, has confounded varieties and species, and recommends the planting of worthless kinds of Eucalypts. There was no Rev. Simmonds (officially) in those days!

In bush planting three things may be necessary (the first a *sine qua non* where there is a dense undergrowth): (1) Cut and mulch; (2) pot or pan transplants; (3) the long-handled swing hoe. The Puhipuhi planting has not had these, with the exception of partial mulching, and that has not been thick enough to kill the fern. The impression I gather is that skilled foresters would have succeeded with the planting, though the work might have been costly and risky. The prospects of the planting now going forward are discussed later under "Plantations." Experience has been gained, and with certain changes the present work should be brought to a successful conclusion and the planting extended to meet railway-sleeper requirements.

The lesson told by the Puhipuhi Forest is that it would have been a matter of everyday forestry to have worked and *preserved* the Puhipuhi Forest, instead of working and *destroying* it. Its destruction, as the event has shown, was a national loss that cannot be replaced, though over £12,000 has been spent in the nominal attempt to do so.

The Object-lesson on the Spot.—Mr. Matthews planted some 450 acres of Totara and it failed absolutely. There is not now a stick left! Near it is a scrap of the original forest left by some accident unburnt. It is a young forest which to see is to admire: the young trees, in the pole stage, Totara and some Kauri, stand close and straight, like White-pine on a piece of swamp land—a forest so easy to work and raise to the highest pitch of productiveness! I must confess that as I walked down to the railway-station that afternoon the impression left on my mind was very strong—the fatuous destruction of such a magnificent forest and the popular notion that forestry consists in cutting down one tree and planting another! Nor has the lesson of the Puhipuhi Forest yet begun to be learnt (see pp. 172–187, "Forest Alienation without Demarcation").

STATISTICS OF THE PUHIPUHI FOREST.

One frequently comes across vague references regarding the millions lost in forest-destruction in New Zealand. It often turns out that such forest was of a class that had to give way to more valuable crops, such as grow on the land at Taranaki. Here, however, at Puhipuhi was most valuable forest on such poor soil that if there had been the faintest shadow of scientific forestry in New Zealand the forest would never have been destroyed. It will be useful, therefore, to examine a concrete case, such as this, in detail, to try and arrive at some reliable figures of what actually was lost when the forest went, more especially with reference to the present question of the Waipoua Forest.

The Puhipuhi Timber worked.

In 1889 the dead and partially-burnt Kauri over the whole area, some 17,000 acres, was measured up, and the records show a total of 128,915,250 sup. ft. This was sold, and £30,687 was paid for some 60 million sup. ft. at the rate of about 1s. per 100 sup. ft. royalty. (Letter dated 8th March, 1919, from the Commissioner of Lands, Auckland.) That this quantity of timber, amounting to three-quarters the present total estimated stand of Kauri at Waipoua, was saved out of the wreck of the Puhipuhi Forest says much for the careful forest administration at Auckland. The comparatively small quantity of the sales is probably accounted for by the timber being sold on sawn measurement and picked over, some of it three or four times, as Kauri got scarce and acquired a value; while all this time there were repeated forest fires. As late as only thirteen years ago the forest plantation official reported (Lands Department Report, 1905–6, p. 32), "On steep rough country where Kauri logs are strewn in all directions this work [planting] is one of considerable expense. . . . There still remains a quantity of useful Kauri timber lying about the reserve which might be profitably utilized. This timber is fast becoming scarce, and is consequently of more value; and it is believed that at the present rate at which it is sold it would pay to convert these previously discarded logs by means of a portable sawmill."

Area.—The area of the original Puhipuhi Forest was about 17,000 acres. The proportion of this area well stocked with Kauri required some care to estimate, and on this point I have been greatly aided by the research made by Mr. F. Mander, M.P., who worked timber in the Puhipuhi Forest for many years. He obtained a plan from the Lands Office and went into the matter, writing me finally, "After thinking the matter over carefully and discussing it with my son, I am satisfied that no more than one-third of the whole block was covered with Kauri, some of it not very densely. Thus the area of actual Kauri forest in the Puhipuhi State Forest was 17,000 ÷ 3 = 5,667 acres."

Mr. H. P. Kavanagh, who was the Government Timber Inspector at that time, tells me he knows of no one better qualified to give an opinion on the matter than Mr. F. Mander. His own opinion is that "the area of good continuous milling-bush represented about one-third of the reserve."

The Original "Stand" of Timber.—From the descriptions given me by those who have seen the original Puhipuhi Forest, and from an unburnt fragment that I have seen, it may be judged that its stand of timber averaged not less than 10,000 c. ft. q.g. per acre. This is not a very high figure amongst forest stands. The Waipoua sample area ("Waipoua Kauri Forest," p. 59) had a stand of sawable timber (quarter-girth measurement) amounting to 5,559 c. ft., and this was about half a first-rate well-stocked Kauri forest. Taking exact European figures (but as an indication only, for it is comparing a cultivated forest with a wild forest), Spruce and Silver-fir in Europe, which as far as we know at present have a rate of growth slower than Kauri, have an average stand in medium-quality forest of 11,350 c. ft. at 120 years of age, or 9,080 c. ft. q.g. The average age of the Puhipuhi Forest trees was at least 200 years, so that their corresponding stand should be about 18,000 c. ft. q.g. Thus for a particularly well-stocked wild forest over such a comparatively small area as 5,667 acres we may safely take 10,000 c. ft. quarter-girth measurement as the timber-stand. Kirk quotes 70,000 sup. ft. of sawn timber as a maximum stand for small areas of Kauri. He says, "Patches of this are not uncommon." 70,000 sup. ft. of sawn timber would represent some 12,000 c. ft. in the log at quarter-girth or squared measurement with the wasteful working of those days, reckoning 1 c. ft. to yield 5 or 6 sup. ft. Now, Puhipuhi is described as a "nearly continuous" Kauri area, the trees looking in places like a gigantic string of candles. so close did they stand. Therefore, when we take 10,000 c. ft. q.g. I think we may rest assured that this is well within the limits of the former stand of Kauri timber at Puhipuhi.

A stand of 10,000 c. ft. q.g. may be analysed in another way. We may compare it with the maximum stands of timber actually milled in New Zealand. The maximum stand of millable timber in New Zealand bush is quoted by the Lands Department at 50,000 sup. ft. ("Forestry in New Zealand," 1909, p. 13). This figure is equivalent to 8,333 c. ft. q.g. in the log. Thus the 10,000 c. ft. assumed here for Puhipuhi, as good a Kauri forest as ever existed, is not one-fifth more than the maximum stand actually milled over various small areas in New Zealand. There can be no reasonable doubt that the original stand of Kauri timber at Puhipuhi averaged not less than 10,000 c. ft. per acre.

Totara.—There was a little Totara in the Puhipuhi Forest. No account was taken of the minor timbers. After the 1881 and 1887 fires, when the remaining large timber was measured up and sold, against 130 million sup. ft. of Kauri, 3½ million sup. ft. of Totara was found, the average size of the Totara trees being 970 sup. ft. The Totara trees, though comparatively small in these northern forests, are reputed to furnish timber of superior quality.

Timber measured up and sold after the Fires.—When the scorched and partially burnt timber was measured up for sale in 1889 after the fires in 1881 and 1887 the official records show totals of 129 million sup. ft.

of Kauri and 3½ million sup. ft. of Totara. The only other timber of which cognisance was taken in the working of those days was Totara. Unlike Australian timber, which is almost always hollow, Kauri is usually sound to the heart; so that fires leave a rich harvest of sound timber ready to haul out easily. I take it that if Kauri-forest fires in the old days had destroyed the best marketable timber instead of making it more easily available, something would have been done to stop them, for, as will be seen later, the fire-protection of a Kauri forest is one of the easiest amongst forests.

Timber-observer's Recollections analysed.

Mr. Crompton Smith, now Chief Draughtsman in the Head Office, Lands and Survey Department, Wellington, in the course of his duties as a surveyor had occasion, in the summer of 1885, to pass through a part of the Puhipuhi Forest before it was destroyed. This was three years before the disastrous fire of 1888. He preserves a clear recollection of the forest, and has more than once described it to me. I have verified his recollections with those of others who had seen this forest, so unique in the forest histories of the world, and who have got it fixed in their memories. Mr. Crompton Smith describes the forest as consisting of trees 3 ft. to 7 ft. in diameter, with 60 ft. or 70 ft. of clean bole, and standing about 15 ft. to 20 ft. apart. Let us suppose that the trees had a mean diameter of 4 ft., a 60 ft. bole, and averaged 18 ft. apart. From centre to centre this distance would be 22 ft., or at the rate of ninety trees per acre. This is about what one sees in fairly fully stocked areas of Kauri forest to-day. I have seen it in patches in Waipoua, in Kauri Park, and in Mr. Trounson's forest. I have little doubt there were ninety trees per acre in the Puhipuhi Forest. I have an estimate from an experienced bushman there of 150 large trees per acre. This might be possible as a maximum over small areas. Such trees, standing so close for their size, would certainly have less than the usual taper. However, to be on quite the safe side, taking the usual taper allowance of 1 ft. girth per 20 ft. length, the mean diameter is reduced to 42 in. A trunk 42 in. mean diameter and 60 ft. long would cube 577 c. ft. gross volume, or 577 less 21·5 per cent. = 453 c. ft. q.g. volume. *Thus we have for the stand of timber per acre ninety trees of 453 c. ft. q.g.* = **40,770 c. ft. q.g.** (or, at one-fourth waste for sawing, 30,578 c. ft. of sawn timber).

This figure (40,770 c. ft. q.g.) may be compared with 40,000 or 50,000 c. ft. q.g., the estimated maximum stand for Karri (*Eucalyptus diversicolor*) in Western Australia ("Australian Forestry," 1915). This high volume for the "stand" at Puhipuhi is due mainly to the small taper of the trunks; in fact, the volume or cubic contents of one trunk of Kauri is about equal to two of Western Australian Karri of the same thickness and height.

But allowances have to be made for irregularities in the stand of timber, particularly in a wild forest of Kauri, and for the immature timber; both foresters and the timber-getters of those days took a high diameter limit for the immature timber—viz., 2 ft.

Let us suppose, then, that Mr. Crompton Smith and others saw the best of the Puhipuhi timber, and that the *average* stand, discounting the irregularity of the wild forest and the immature timber, would only be about one-quarter of the *maximum* stand which they saw, or, in round numbers, some 10,000 c. ft. (quarter-girth measurement). This accords more with Mr. Buckhurst's estimate mentioned above, p. 56.

As mentioned above, the stocking according to Mr. Mander could not be considered regular, and there was much young timber. Nevertheless, when all is said, in taking the average at one-quarter the maximum it is taken undoubtedly very low.

Puhipuhi Timber "Stand" and European compared.—This 10,000 c. ft. q.g., is, in fact, what I have assumed as the stand of the normal cultivated forest of the future in New Zealand. It compares thus with European data. I have elsewhere pointed out that Kauri in New Zealand has an average growth about one-third faster than first-class Oak in mid-Europe. Turning to Schlich's Yield Tables (vol. 3, p. 344) I find that first-quality Oak forest at 200 years of age (computing onwards from Schlich's last figures) will have a stand of about 8,834 c. ft. q.g. This figure affords a useful check, since the age of Mr. Crompton Smith's average tree at Mr. Cheeseman's growth-figure, as will be seen presently (Trans. N.Z. Inst., vol. 46, p. 14), would be about 230 years. But Oak forest as it ages thins out rapidly, and that reduces its volume of standing timber per acre. If I make the comparison with mid-European first-quality Spruce, which in rate of growth and form much resembles Kauri in the "ricker" stage, I find that at age 120 there is a stand not far off double that of first-quality Oak. All of which goes to prove that 10,000 c. ft. here taken as the Puhipuhi stand of timber in the virgin forest is a very moderate estimate. It probably errs on the lower side.

Total Timber, Puhipuhi.—10,000 c. ft. q.g. × 5,667 acres = say, 57 million c. ft. q.g., the original Kauri timber stand of the Puhipuhi Forest. At one-fourth loss in sawing this represents 513 million sup. ft. This may be compared with the 60 million sup. ft. (as above, p. 60) actually sawn and accounted for.

Timber-growth Figure (Acrim) of 219 c. ft.*—I examined a number of Kauri stumps at Puhipuhi. Many showed "dominated heart" for 2 in. or 3 in., with rings not broader than $\frac{1}{32}$ in.: thence up to 2 ft. radius the rings would run from $\frac{1}{4}$ in. to $\frac{1}{8}$ in. broad, which, of course, show quite a rapid growth.

It will be objected that the observers of thirty years ago may have exaggerated or faded recollections. To this there is the answer that many observers have given me their recollections and that they agree in the main. I have taken Mr. Crompton Smith's recollection here because, as a Government surveyor accustomed to the "bush" country and to dealing with quantities and magnitudes, his figures are least liable to error. But there is a quite independent check on his figures in Mr. Cheeseman's investigations on the growth of Kauri. As above, Mr. Crompton Smith's average tree is 4 ft. diameter at the base and 60 ft. in the bole. A 4-ft.-diameter tree, according to Mr. Cheeseman (Trans N.Z. Inst., vol. 46, 1913, p. 14), would be 24 in. radius × 9·7 years = 232·8 (say, 233) years old. Dividing "stand" by age one arrives at the acrim (average production of timber per acre per year). Therefore, as above—

$$\frac{\text{" Stand " } 40{,}770 \text{ c. ft. q.g.}}{\text{Age } 233} = \text{Acrim } 175 \text{ c. ft. q.g.}$$

or 219 c. ft. full cubage acrim.

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* "Acrim" is a term used by South African foresters to mean the annual increment in cubic feet of one acre of growing timber. (C.E.L.P., in "Australian Forestry.") It is more fully explained at p. 91.

Here we are on firm ground. An acrim of 219 c. ft. may be compared with any of the published Forest Yield Tables, with the list given in my "Forestry in Cyprus" (Colonial Office, 1909), with various references in "Australian Forestry," or with the list in the Statistical Appendix (Part II). An acrim of 219 c. ft. full cubage is undoubtedly high for a wild forest average. As above, I have taken one-fourth of it.

The following recorded "stands" of timber, in addition to those mentioned above and on p. 85, afford an interesting comparison with my estimate of the original stand of Kauri at Puhipuhi :—

TIMBER "STANDS."

VARIOUS STANDS OF TIMBER (PER ACRE) FOR COMPARISON.*

	C. ft.	Sup. ft.
Sample area recently measured at Waipoua increased to a full stand (McGregor's maximum)	11,000	66,000
Kirk's maximum, as above	12,000	72,000
Maximum stand over small areas of millable timbers in New Zealand ("Forestry in New Zealand": Lands Department, 1909)	8,233	49,398
Average stand, Black Forest, Germany, when they are starting the regeneration cuttings	9,000	81,000
Average stand Spruce and Silver-fir ("Yield Tables," Schlich), medium-quality forest, at 120 years of age	8,500	76,500
Podocarpus forest of South Africa (same class of forest as "mixed" New Zealand)—maximum recorded (Fourcade)	10,000	90,000
Normal stand of the cultivated Kauri forest—107 Kauri trees of 93 c. ft. q.g. each (taking 1 c. ft. = 9 board feet) ..	**9,951**	89,559
Average stand assumed for the Puhipuhi Forest, at a quarter of the maximum as described by various observers	**10,000**	60,000

Thus the average stand taken for the Puhipuhi Forest is actually no more than the figure assumed for the normal cultivated forest of the future (p. 84). I wish it to be remembered that in this Puhipuhi discussion I have everywhere taken the lowest figure possible.

THE LOSS—(*a*) VIRGIN FOREST, (*b*) FUTURE TIMBER CROPS.

THE LOST TIMBER CROP OF THE VIRGIN FOREST.

During the quarter-century when the Puhipuhi Forest was being gradually worked and burnt, Kauri sawn timber was worth about 10s. per 100 sup. ft. (Kirk, p. 154), while the royalty value or stumpage had a nominal value of from 6d. to 1s. per 100 sup. ft. If there had been a forest policy in those days the Kauri forests would have been demarcated, organized with roads, &c., and the Kauri timber worked at half or one-third of what it has cost to extract without roads, while the royalty would have borne some relation to the market value of the timber. Under the abnormal forest policy followed the prices of those days signify little.

The royalty of thirty years ago—6d. to 1s. per 100 sup. ft. on the mill output—represented perhaps 3d. to 6d. per 100 sup. ft. in the squared log. But this 3d. or 6d. per 100 sup. ft. was not the market royalty or anything like it—viz., the value left after deducting the cost of logging, sawing, and putting the timber on the market. The Government royalty of those days was an arbitrary value fixed partly by political pressure and partly by the laudable desire to develop the country. It was influenced by the Australian rates, which represented nothing except a forestry worse even than the New Zealand forestry of those improvident days. On the one hand there was the fact that the wild forest represented an idle capital earning nothing, and so the sooner it was worked the better (p. 109, "Australian Forestry," by the author); on the other hand the fact that the destruction of the wild forest without demarcation was an absolute national loss—no better and no worse, in fact, than strewing Bank of New Zealand notes about the streets for the first-comer to pick up! The forest policy of those days should have been forest demarcation, and the rapid development of the demarcated forest by means of a forest loan, which with the collateral security of the forest could have been raised on more favourable terms than the ordinary public loans. Even without development foresters could with *jardinage* ("selection") fellings have made the working of the forest pay, protecting it from fires, and starting it making a genuine though small timber increment (acrim).

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* In the above stands of timber 1 c. ft. q.g. is taken as equal to 6 sup. ft. for old New Zealand figures to allow for the wasteful log-working of those days. It may be noted that 1 c. ft. standing-log measurement = 6 board feet is a general official American factor. The European and South African figures are taken 1 c. ft. = 9 board feet. This allows for rather poor milling (a 25-per-cent. waste) but no waste otherwise The European log is reckoned down to 3 in. diameter at the small end. This end piece is allowed for in the wasteful working of New Zealand forests.

Thirty years ago Kauri was better known on the English market than now, and the big Australian softwood market, following the reckless destruction of the small supply of Australian softwood ("Australian Forestry," p. 119) was then active. Thus in attempting to arrive at some approximation of the value of the Kauri timber wasted in the Puhipuhi Forest it would be futile to take current royalty or stumpage values of those days, because, in the absence of a forest policy, they represented nothing except a reckless extravagance, which many future generations of New-Zealanders will have to pay for, come what may.

During the last few years the making of roads and railways has made the remnants of the Kauri forests fairly accessible to the world's markets, so that prices to-day are beginning to give some indication of what is the real value of Kauri timber on the world's markets. The present auction or public-competition royalty on Kauri represents to a considerable extent its market value, though it is still unduly lowered by the absence of much competition and the bad traditions of a half-century of "throw-away" rates. Owing partly to industrial development and partly to the absence of national forestry, the English timber-market is by far the most important, and governs the prices of timber absolutely in the case of those timbers that are able to reach it. So that the high place Kauri has had on the English timber-market is the best indication of the intrinsic value of the timber.

PRESENT-DAY VALUES: TIMBER OF THE VIRGIN FOREST.

Let us consider, therefore, the value of the Puhipuhi timber at present-day prices, and with the better milling now in vogue. With a 25-per-cent. milling-waste (no longer the 50 per cent. of the old days), 10,000 c. ft. q.g. stand × 9 = 90,000 sup. ft. per acre. This figure multiplied by 5,667 acres = 510,030,000 sup. ft. I take 10s. as present-day royalty, on account of the quality, accessibility, and easy working of so good a stand of timber as was that at Puhipuhi.

Present-day Values: Puhipuhi Timber.

	£
Royalty-value: 510 million sup. ft. at 10s. per 100 sup. ft.	2,550,000
Sawn timber average net value: 510 million sup. ft. at £1 5s. per 100 sup. ft. ...	6,375,000

These two figures represent, in round numbers—two millions and a half lost to the Public Treasury, and an industrial loss of some six millions and a third production in New Zealand; and what is more, production of a raw material—timber.

Against this loss there is nothing to set except the grazing on the burnt forest land and the proportion of timber worked up during and after the burning of the forest—viz., 60 million sup. ft.—together with the saving (a drop in the ocean) of some few thousands a year in the local cost of a Forest Department to look after the timber and protect the forest from fire. The Land Commissioner's forest staff at this time included well-chosen and able men; but then, as now, it was a mere skeleton Forest Department consisting of untrained men, without skilled direction—as powerless in the field as would have been five firemen stationed at Palmerston North to protect the City of Wellington against fires!

An efficient local forest staff for the whole Puhipuhi State Forest, including both the Kauri area and the mixed Totara and other forest, would have cost some £2,000 or £6,000 a year, according to the measure of intensive working resolved upon. This, as mentioned above, would have sufficed to have thinned out, regenerated, and put an economic timber increment on to the younger trees left, Government doing its own logging, sawmilling, and exporting, as the timber had so low a local value. The profit of this moderate exploitation would have been compared at intervals with the timber increment gained and improvement in the condition of the forest, as determined by competent foresters. Or the forest might simply have been closed down, as the Waipoua Forest has been; but this would have been at the cost of loss of revenue and loss of forest-improvement.

Whichever of these plans were adopted, there would, of course, have been full intensive working as soon as the railway arrived on the spot, with the profits and costs of working set forth approximately at p. 95, "Balance-sheet of a Normal Kauri Forest." The working-costs then would have been about £20,000 a year—viz., 5,667 acres at an average cost of £2 per acre (employment in the normal forest), and 11,334 acres at about 15s. 8d. per acre during the transition period. The value now being obtained for the land under dairying—a poor business compared to the scientifically worked Kauri forest—is considered below. So much for the value of Puhipuhi timber.

LOST FUTURE TIMBER CROPS OF THE PUHIPUHI FOREST.

Serious, however, as was the loss in the burning and wasteful working of the Puhipuhi Forest, this was eclipsed industrially in the permanent loss to New Zealand of so rich an inheritance in this fine forest estate. The loss of the virgin-forest timber may have represented 230 years' forest growth; but behind that lay the economically greater loss in the capital value of the forest as a national asset, lost to the country for all time.

The virgin-forest timber of the Puhipuhi Forest (with a present-day royalty value of two millions and a half, and a sawn-up value of six millions and a third) represents after all but one crop of timber, while the forest, under modern forestry care, would have continued to produce crops of timber in perpetuity. When the crop of virgin timber was worked off that should have been succeeded by more valuable crops of regrowth timber, since this (under foresters' care) would have been in denser stand, straighter, and more uniform in size. Now, what would be the value capitalized of the future timber crops from the cultivated forest?

The 17,000 acres of the old Puhipuhi State Forest was composed (p. 60) of (*a*) some 5,667 acres of pure Kauri forest, and (*b*) 11,334 acres of scattered Kauri, Totara, and mixed forest. There are only partial records of the value of the timber on (*b*). The value of the timber on the 5,667 acres of complete Kauri forest discussed above would be as follows:—

It was remarkable for the quantity of young Kauri it contained, so that foresters could have treated it straight away as a normal Kauri forest, and the revenue and expenditure would have been those shown at page 98, less some deduction for the fact that at the next cutting in twenty to forty years Kauri might not yet be fully double its present value. On the other hand, the acrim in this world's best Kauri forest would naturally be more than that (100) assumed for the normal Kauri forest. I will therefore value on the basis of the normal Kauri forest, being practicable now, without any transition period. Then 5,667 acres × £270 (the capitalized value of the normal Kauri forest, p. 99) = £1,530,090.

Summarizing the national loss in the destruction of the Puhipuhi Forest, we have:—

LOSS IN DESTRUCTION OF PUHIPUHI KAURI FOREST AREA.

	£
Value of the Kauri timber in the virgin forest at present-day royalty rates of Kauri ...	2,555,150
Loss of future Kauri crops, adopting only the figures of net value for a normal cultivated Kauri forest (p. 99) and capitalizing at 4 per cent.	1,530,090
Gross loss	4,085,240

At first sight it may seem remarkable that the capitalized value of all the timber crops should be less than the value of the one heavy timber crop from the virgin forest; but the first figure here is the accumulation of some 233 years of unreaped Kauri crops ready to be cashed, while the time-element lays a heavy discount on the present value of future timber crops. Comparative values of present and future timber crops in the normal Kauri forest will be found at p. 99. All the above calculations are on a 4-per-cent. basis. As mentioned at p. 99, 2½ per cent. and 3 per cent. are commonly accepted forest percentages in Europe. At 3 per cent. the capitalized value of future timber crops at Puhipuhi would be 5,667 acres × £360 (p. 99) = £2,040,120.

THE LOST FOUR MILLIONS—WHAT HAS BEEN GOT FOR IT?

As a set-off against the loss of over four millions in the destruction of the Kauri forest there are two items:—

(1.) The grassing, dairying, and grazing over some 5,667 acres of Kauri forest on poor or very poor soil. As mentioned, at my visit to Puhipuhi I was informed that the average earnings of a family occupying 200 acres and dairying (including pigs and calves) averaged about £200 per year gross, or £100 per year net, allowing 50 per cent. as the cost of labour. When the labour is deducted we get at the value of the raw product, the grass, directly comparable to timber royalty. Supposing that three-quarters of the area can be successfully grassed, one arrives at an area of 4,250 acres earning at the rate of 10s. net per year, or £2,125. This figure at 4 per cent. capitalizes to £53,125.

(2.) Kauri timber sold after the forest had been burnt: 60 million sup. ft. at 1s. per 100 sup. ft., with interest at 4 per cent. for twenty years—£60,000.

Thus in the destruction of the Puhipuhi Forest the profit and loss account stands to-day thus:—

	Dr. £	*Cr.* £
Virgin forest Kauri timber at present-day rates	2,555,150	...
Capitalized value of future forest timber crops	1,530,090	...
Capitalized value of grass (dairying) on 5,667 acres ...	...	53,125
60 million* sup. ft. of Kauri timber sold, with interest to date (twenty years at 4 per cent.)	...	60,000
	£4,085,240	£113,125

Thus the net loss in the destruction of the Puhipuhi Forest has been **£3,972,115.**

The bulk of the timber was sold by 1900 (see litho plan in office of Land Commissioner, Auckland). The average royalty was 1s. per 100 sup. ft. of sawn output.

So that for the *ignis fatuus* of settlement £4,085,240 worth of timber and forest was lost to the nation, against £113,125 worth of grass value and timber saved; all these being final or capitalized values, brought up to date at 4 per cent. compound interest.

Dividing by the acreage (5,667):—Loss per acre (gross), **£720**; loss per acre (net), **£701.**

EMPLOYMENT AT PUHIPUHI: DAIRYING AND FORESTRY.

It might be thought that though the loss of over four millions in the destruction of one little Kauri forest of under 6,000 acres was shockingly bad finance there would be some set-off from an employment and settlement point of view; but here again the balance is all on the side of the Kauri—which is perhaps to be expected, since Kauri is here the most valuable product of the soil, and it is the soil put to its best use that supports most men on the soil. Employment at Waipoua and in cultivated forest generally is discussed at p. 49, "Waipoua Kauri Forest," and p. 94 here. The following is a sketch of what it would have amounted to in a particularly well-stocked forest, such as was Puhipuhi :—

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* This figure is excessive. It represents not only the timber sold off the fully stocked area which I am here considering, but the timber on the remaining two-thirds of the area of the forest which was partially stocked with Kauri. The excess, however, compared to the total figures is small—about £15,000 in a total of £4,085,240; and it is a sound principle that if one has to err in framing an estimate let it be on the moderate or conservative side.

First Period.—The labour on logging would have been less, but not to any great extent; while during the first stage of forest organization, when the virgin forest was being worked and regenerated, there would have been the great contrast in employment between a handful of struggling pioneer settlers and the extensive Government-paid labour required to organize the forest with roads and buildings. The amount of this organization expenditure would have depended on whether the forest was to be worked intensively or extensively. In a Kauri forest it would naturally be the former, and in a forest such as was Puhipuhi particularly so. During this period, therefore, Puhipuhi would have been a busy hive of human industry, and the cost of this would have been easily defrayed out of the Kauri saved from the burning and waste. This period would have occupied some eight or twelve years or longer, depending on the demand for Kauri; and as long as it lasted there would be no comparison between forest and grass employment. Perhaps the most important point here from a settlement point of view is the precious aid in ready cash which would have been afforded to the pioneer settler of the neighbourhood, helping him over the difficult early times. "It never has been true national economy to leave the utilization of virgin country to solitary settlers, provided with inadequate implements and insufficient capital." (*Auckland Weekly News*, 16th August, 1917.)

Second or Transition Period.—Here, between the cutting of the virgin forest timber and the ripening of the regrowth, is the period of least activity and least employment, the "transition period" of the "normal Kauri forest." Taking nearly the figure given at p. 97, average employment for the period would have been about one man per 160 acres, plus four or five Forest Rangers for the whole forest. This is well in excess of dairying employment, even if all the lots had been successfully grassed, which is not likely to have been the case on the poor soil at Puhipuhi.

Third or Normal Forest Period.—Here the forest is in a nearly normal condition, and employment would have been also nearly normal. The process of straightening out the age-classes might have caused some temporary irregularity in the employment, but would not have affected the average of employment for the period. Taking ordinary European rates (see "Balance Statement," p. 94), employment would have been at the rate of one man per 75 acres, or more than *double dairy employment at its best at Puhipuhi.* Thus, compared to dairying (so far as the grassing had been successful) cultivated Kauri forest here would have given at first much greater employment, then for the transition period of about a hundred years a little more employment, and thence onwards and *always afterwards* double or treble the employment on dairying.

This striking contrast is rendered more startling when one considers that it requires a hard-working man to make a precarious living at dairying or sheep on this poor soil. The Hon. the Prime Minister is reported as having said lately (cost of living): "No man in the community worked harder than the dairy-farmer, yet statistics showed that at the end of the year they only made from £120 to £150." It is very doubtful if the 16,000 acres of burnt forest at Puhipuhi will ever support eighty families on dairying at Puhipuhi. On the other hand, any able man, with work in the forest and cows or sheep on an adjoining farm, could have made his £250 a year out of the two combined—the usual European procedure.

Cost of replanting Puhipuhi with Kauri.

To replant the Puhipuhi Forest (allowing interest at 4 per cent. and maturity at 100 years, and supposing thinnings paid the cost of maintenance, which may be assuming too much) would cost over £12,000,000. Thus, taking full planting at £15 per acre, the cost without ground-rent would be—17,000 acres × £15 (planting) × 50·5 (interest at 4 per cent. for 100 years) = £12,877,500. A more detailed calculation is given at p. 166.

Summary.

Large though the figures of the loss at Puhipuhi are, and recording as they do a great national disaster, they are easily credible, bearing in mind that as late as the year 1908, when the Kauri industry had declined considerably, the Auckland mills turned out over £1,000,000 worth of timber, mostly Kauri, while well over £250,000 worth of timber was exported from Auckland. The Auckland mills gave employment then to 3,600 hands; and besides this "between four thousand and five thousand hands were engaged in bushfelling and other occupations in connection with the timber industry" (Lands Department Forest Report, 1909, p. 17).

The figures of the value of the Waipoua and Puhipuhi forests, though they mount up to huge totals, are not exaggerated. I have carefully verified them. The items on which they are founded are all moderate, as will be seen by corresponding items discussed elsewhere in these pages. They may be compared with some £1,500,000, the total value of all the freezing-works in the Dominion before the war. Freezing-works are in the public eye—the least neglect of their interests by Government would be at once resented, and rightly so. But this valuable Puhipuhi Forest, with its majestic trees, slipped quietly out of sight because there was no forest demarcation to separate it from the original bush requiring to be cleared for settlement, and because there was no Forest Department to take it in charge.

Locally, when the rich forest was turned into a fern waste, or at best a poor grazing-area on impoverished soil, the countryside lost half its industry and population, together with those amenities to country life which go with a larger population—better roads, better shops, and better postal facilities and social intercourse.

Some small portions of the Puhipuhi area are suitable for plough or hand cultivation, and under intense cultivation these might have yielded more money and employment than under Kauri forest and its products. Such lands, with the abundance of Kauri forest in those days, could have been demarcated out. They would have been particularly valuable as residential areas for the forest workmen or for those farm-and-forest holdings that succeed so well on the Continent of Europe, and are now being so strongly advocated for the greater success of small-holding settlements in the British Isles.

The Lesson of the Past.—I have taken out these figures not with the view of criticizing what was done long ago. One must not judge too severely the reckless forest waste of thirty or forty years ago, for the New-Zealander of those days came mostly from a country (England) where State forestry was tabooed, and he was very short of cash. Says W. Pember Reeves, "Public affairs during the decade (1880–90) resolved themselves chiefly into a series of experiments for filling the treasury and carrying on the work of land-settlement."

But nowadays, when New Zealand is rich beyond the dreams of thirty or forty years ago, and with the proud boast of the best war record of any of the dominions, when only two great wants remain—population and a forest policy—it is useful to glance back and face the figures showing what was lost to the country when the best Kauri forest it ever had was allowed to be destroyed without demarcation.

Writing under date 9th May, 1917, the Commissioner of Lands, Auckland, in a letter to me says, "I quite agree with your remarks regarding the irreparable loss of this [the Puhipuhi] forest. It shows clearly the necessity for the protection and conservation of the Waipoua Forest."

The Picture not overdrawn.—It is as clear as daylight that the national loss in the destruction of the Puhipuhi Forest is not over-estimated. The recollections of those who knew the forest have been discounted down to a general timber stand not exceeding heavy stands of similar timber elsewhere. To allow for the irregularities in the timber stands of most wild forests I have taken the Kauri timber stand at Puhipuhi as little more than one-fourth of what careful observers say they saw. It is true that I have taken present-day prices of Kauri timber. But when the Puhipuhi Forest was destroyed it was evident that these values must come. Laslet, the well-known Timber Inspector to the British Admiralty, had said as much after his visit to New Zealand. (Trans. N.Z. Inst., vol. 46, 1913.) As an illustration of the direct money loss in the Puhipuhi Forest these comparisons may be made:—

Comparisons.—If "Greater" Wellington were to be totally destroyed by an earthquake worse than that of San Francisco, it could be entirely rebuilt (with better-graded streets and the boulevards its peerless site merits) for what would have been the value of the Puhipuhi Forest at present prices, and supposing the whole forest of 17,000 acres to be fully stocked with Kauri as a normal Kauri forest—viz., £11,916,000 net. The official valuation of the present buildings, streets, and all "improvements," except harbour-works, is £8,864,855 (Corporation Year-book, 1916–17). And the area of this forest, whose destruction has cost the country so dearly, was less than that of Wellington Harbour from the sea to Somes Island (p. 179)!

Again, the total value of all the Kauri "gum" exported up to date, under £18,000,000, is not equal to twice the value of this one Puhipuhi Forest taken as above; and the total value of all the coke and coal produced in the Dominion up to now is only a little over the value of two Puhipuhi Forests.

INDUSTRIAL LOSS TOWARDS £12,000,000.

Behind this direct money loss is the industrial loss. Kauri sells now (1918) at £1 8s., boards, medium quality, per 100 sup. ft. at Auckland. This is about three times the present market royalty, or stumpage value.

of well-placed good timber. If the royalty loss on the Puhipuhi timber has been near £4,000,000 (p. 67), the industrial loss is therefore somewhere near £12,000,000. It is true that a large part, possibly the larger part, of the scorched and worm-eaten timber was sawn up and thus provided work and wages. But that this was not much to deduct from the £4,000,000 is shown by the comparatively small total amount that was recovered as royalty on all timber worked (p. 61). And this does not take account of indirect losses in railway transport, handling, timber-merchants' profits, and economical raw material for carpentering, furniture-making, and other trades. It was a black page in the industrial history of the British Empire when the Puhipuhi Forest was burnt! It was on a par with the depopulation of the Highlands of Scotland when the crofters and their industries were driven out to make room also for sheep, their industries, fishing, land-cultivating, and timber-working. The Highland glens still show unmistakably the fine forest that once grew there—forest of Scotch-pine with brown-coloured durable wood smelling like cedar.

From a forestry point of view the destruction of the Puhipuhi Forest was anarchy in one of the most important branches of the administration of a civilized country! Undoubtedly that would be the view taken by a Frenchman, a German, a Japanese, or the inhabitant of any country with its forestry organized on modern lines.

The excesses of the Commune in 1871 cost Paris some solid millions; but a large part of that came back in wages, and it all happened in a few days. The Puhipuhi industrial loss of £12,000,000 was spread over twenty-five or thirty years, and of that loss but a fraction came back in wages. Once or twice each summer there was a blood-red haze in the western horizon!

As a contrast the following mnemonic summarizes the improvement in Prussian forests during an average lifetime of about seventy-four years:—

Increased yield Prussia in a 7–4 life,
Was nine times timber and more'n ten times gold
Up to ten years before the present strife,*
And the Forest Department one-forty years old.
Prussian timber, 1830, one penny the cube†
But a metric ticky‡ before the great feud.*

---

* The war of 1914. † = 1 cubic foot, a phrase used in countries where the cubic foot is the unit of timber-measurement. ‡ South African term for the smallest silver coin, 3d. The metric ticky = 2·4d. or £0·01.

FORESTS OF THE NORTH: THEIR MANAGEMENT.

OUTLINE OF A GENERAL "WORKING-PLAN."

THE KAURI TREE OF THE FUTURE (2 FT. DIAMETER BY 60 FT. BOLE).

THOUGH a certain number of Kauri trees will be allowed to grow to a larger size for special uses and scenic purposes, the Kauri tree of the future must evidently be one which will mature in about 90 or 100 years, to avoid piling up interest charges. It will be useful, therefore, to inquire what will be the size of the Kauri tree at that age. For his younger trees Cheeseman's figures show an average of eight rings per inch of radius = four rings per inch of diameter. Thus a tree of 24 in. diameter would average about 96 years of age.

The amount of sapwood on such a tree I discussed with Messrs. Pollock and McGregor, the two expert timber-men of the Lands Department, Auckland. They agreed that a 2-ft.-diameter tree would not average more than 3 in. or 4 in. of sapwood. (See also p. 21.)

The Hon. E. Mitchelson, who knows Kauri intimately, both in the forest and as a cultivated tree, and with whom I had the advantage of discussing the Kauri tree of the future, is of opinion that Kauri will be of a workable age in 80 years, timber corresponding to that size being now cut at the mills; but he would prefer Kauri timber 2 ft. 6 in. in diameter and 130 years old. Mr. Cheeseman's opinion is similar. The late Mr. Matthews found regrowth Kauri trees in the Waitakerei Hills, 1 ft. in diameter, that could not be older than 25 or 30 years, and might be less (p. 125, "Natural Regeneration"). It will be remembered that Kauri takes less time to grow its second than it does its first foot in diameter.

2 ft. Diameter at 100 Years.—It seems therefore right to conclude that the Kauri tree of the future, grown in the cultivated forest for economical forestry, will be *a tree about 100 years old and 2 ft. in diameter*. This is a safe average estimate. It may be somewhat younger or larger. At 100 years Kauri is in its most active growth-period, so that, except for the severe money interest charge on its high value, there would be no important loss in letting these 100-year-old Kauri trees run on for a few years more till the proportion of heartwood was larger. It would be just a matter of calculation as to how far a better market price would pay the increased interest charge on an older tree.

Kauri trees are now being cut at certain mills down to 1 ft. diameter, but these are one-half or more sapwood; trees not smaller than 2 ft. diameter are preferred. It must be always remembered that Kauri sapwood has valuable qualities not possessed by the sapwood of all trees (p. 21).

I take the Kauri tree of the future as having 60 ft. of bole because well-grown and close-grown trees will have this length of sawable stem, and where the trees are less well-shaped there will be a notable quantity of furniture-wood in the branch-wood to make up for the shorter bole.

Ideal Tree of European Foresters.—In central Europe foresters aim at producing a stem about 1 ft. in diameter and 60 ft. long (reckoning stem down to 3 in. diameter), and it takes 90 or 100 years to grow such a tree. Kauri in the same time will grow about 2 ft. in diameter and 50 ft. to 60 ft. in bole, reckoning bole down to about 1 ft. in diameter. This is, as we know, the trees in good wild forest. In the cultivated forest the stems would be more numerous, perhaps taller, but probably of less diameter. At the same time the total sectional area of the stems would be more in the cultivated forest.

CUBIC CONTENTS OF THE KAURI TREE OF THE FUTURE.

As mentioned, the noble old Kauri tree centuries old is not the economic tree, so valuable in the cultivated forest. It is curious what a quantity of picturesque writing on New Zealand forestry is founded on this quite erroneous assumption. (See p. 8 of "Inaugural Address" of the New Zealand Forest League.)

In mid-European forestry Spruce gives usually the best returns, and its rate of growth in the best quality of forest resembles that of the standard timbers in New Zealand—Kauri, Totara, and Rimu. In first-quality European Spruce forest at the age of 80 years (when the timber acrim is at the highest—viz., 200 c. ft.) the average tree is 1 ft. in diameter and 93 ft. total height. In Spruce forest of average quality (when the timber acrim is barely past the maximum—viz., 140 c. ft.), at 100 years of age the average tree is 10 in. diameter and 79 ft. high (Schlich's Yield Tables). This is an indication only of what should be the economical size of the Kauri tree of the future, for Kauri must be grown larger in order to get a fair proportion of heartwood.

A Kauri tree 2 ft. diameter under bark at base (or, to speak quite accurately, above the base bulge, which is very small or sometimes quite absent in Kauri) and 60 ft. of bole, if one allows 5 in. of diameter for taper to the centre of the trunk, would cube 118 c. ft. This is the true volume. Taking what is approximately the cubic content of the squared log by the English log rule of "the square of the mean quarter-girth" (Hoppus), the *Kauri tree of the future will have a cubic content of 93 c. ft. quarter-girth.* Allowing 25 per cent. for waste in sawing, 93 c. ft. q.g. would represent 837 sup. ft. of sawn timber. If, however, one took the "two-thirds-diameter squared" log rule which is used in nine States of the United States of America, the superficial feet would work out to 801·4 sup. ft., or 890 board feet, taking Professor Somerville's general factor for the chief American log rules. As will be seen later, I take rather more height and less taper than the average Kauri, as the "Kauri tree of the future" will be a tree grown in close forest; and I assign it a cubic content of about 100 c. ft. quarter-girth measurement.

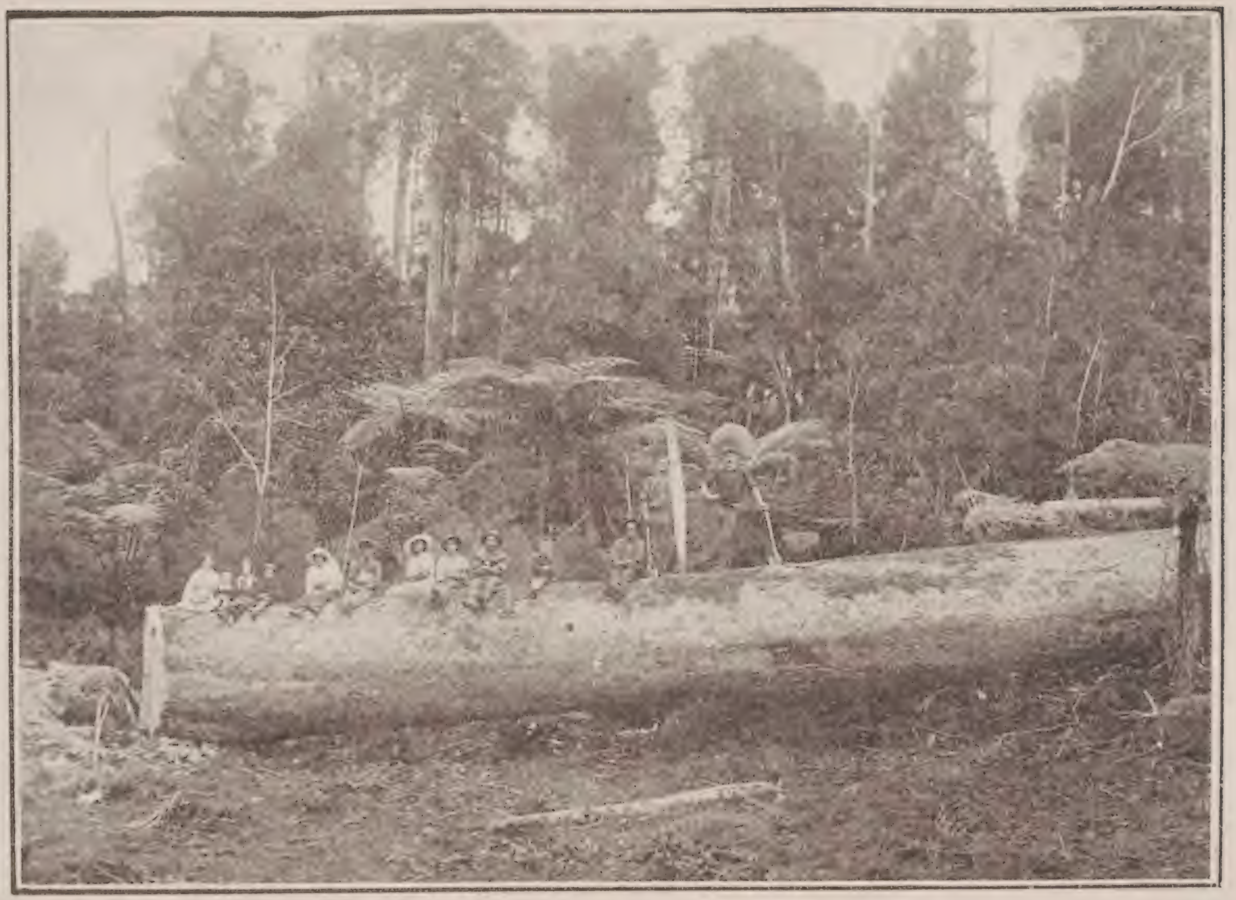
A good illustration of the Kauri tree of the future will be found at page 61 of Laing's "Plants of New Zealand."

Mr. Phillips Turner estimates the average Kauri tree of to-day as one that will yield 3,000 sup. ft. of sawn timber. Taking 10 sup. ft. = 1 cubic foot (p. 77) that would give to the average Kauri tree now in the forests a volume of 300 cubic feet, or three times the size of the economic tree of the future unless it be found expedient to grow the latter rather larger.

LOG-MEASUREMENTS: EXPLANATION.

Quarter-girth.—It is not easy to follow the figures below without some explanation of what is understood by the various log-measurements referred to. The miller uses the term "superficial feet" or "board

PLATE XI.



LOG-MEASUREMENT: A KAURI LOG.

[*To face p. 74.*

feet," and that is enough for his purpose; but this brings confusion as soon as one gets into forestry and the measurement of timber in the log. If one uses board feet for timber in the log, as in America, there is the confusion between 1 c. ft. = 12 sup. ft. plain measure; and 1 c. ft. = 6 to 9 sup. ft. for the converted log, according as the log is sawn or otherwise worked up.

Ordinarily, timber in the log is measured by the cubic foot. But confusion has been caused by the insular practice that started in England of a cubic foot of timber being taken smaller in order to represent something nearer the squared content of the log. The English squared-log cubic foot is 21·5 per cent., or approximately one-fifth, below the true cubic foot. As mentioned above in these pages a true cubic foot is written "c. ft."; the smaller British foresters' cubic foot is written "c. ft. q.g."—*i.e.*, cubic foot quarter-girth.

It is unfortunate that New Zealand should have taken over these old rule-of-thumb Hoppus tables and quarter-girth measurements from England. Their use alongside true cubic contents of logs causes confusion, since a cubic foot in a log means one thing and a cubic foot in sawn or other timber means a true cubic foot. In South Africa only the true cubic foot is used, whether in the log or in sawn timber. The British quasi cubic foot must be looked upon as part and parcel with English weights and measures, coinage, and spelling, which most other nations have rectified long ago—the French after the French Revolution, the Germans in 1870. British people have more to do with buying timber than producing it, more to do with the squared log on board ship than the round log of the forest. Hence their adoption of quasi squared log-measurement. The British "load" of timber = 50 cubic feet, sometimes quarter-girth and sometimes true.

New Zealand Government System of measuring Timber.—The Government system of measuring Kauri timber in New Zealand is to take the height with an Abney level, girth the base with a tape, and book that with an allowance for taper, which may be 1 ft. girth (or 4 in. diameter) in 20 ft. or 40 ft. according to the actual taper on the tree. Bark is taken as being 1 in. thick. Sapwood in dead trees and other defects are allowed for. (Pollock, Forest Commission, p. 52.) The cubic content is then taken out by Hoppus tables. Perhaps when New Zealand adopts better forestry the antique Hoppus tables may be discarded, and then the confusion of two cubic feet meaning different volumes will cease.

For many purposes in New Zealand one may say "1 c. ft. = 12 sup. ft.," but when one considers the relation between cubic feet in the log and superficial feet of sawn timber it is usual to take the circumstances of the case into consideration: (1.) There is the waste in working the standing timber in the forest. At present, except in the North, the miller takes what he likes and leaves the rest, and pays on what he takes. (2.) The sawing-waste depends on the description of sawing followed. In America the official relation is 1 c. ft. stumpage = 6 board feet. With less wasteful working it is 1 c. ft. = 9 sup. ft.

Waste in sawing.—Mr. H. P. Kavanagh in his evidence before the Forest Commission assumed a waste on sawing the Waipoua timber of one-third, *after quarter-girth measurement*. That, however, represents working where timber is of little value, in an undeveloped forest, and where machinery is wasteful. A rough circular saw may take a toll of nearly $\frac{1}{4}$ in. of sawdust in cutting a 1 in. plank. Small sawmills cannot be avoided where the stand of millable timber is low or scattered, but the penalty in wasteful working is often high.

The secretary of the Kauri Timber Company (Timber Commission of 1909, p. 565) and the manager of the large Ruatapu Mills on the West Coast (Forest Commission, p. 57) both estimate their sawing-waste at 25 per cent. Forbes, the well-known Irish forester, has estimated the general sawing-waste in England at one-quarter; the sawmills (as, indeed, in Europe generally) are often small and wasteful.

With band-saw sawing, and the much more complete utilization of Kauri timber now and in the future, I shall take one-fifth as a liberal allowance for Kauri sawing-waste in the future. This then gives twice one-fifth as the total deduction from the volume of sound timber of logs in the round—viz., Squaring as given in Hoppus's, Maw's, or other English tables, really 21·5 per cent., say one-fifth loss; sawing-waste on sound squared logs, less utilizable branch-wood in the crown, again one-fifth, so that the total two-fifths comes very near the common general rule of one-half waste.

Into the "welter of American log rules" it is not necessary to enter here. They are convenient millers' rules used in sawing-practice. They express for the various classes of logs the number of board feet the log will yield when well sawn up.

True Cubic Content.—Those who defend "quarter-girth" cubic foot say, Why trouble about the true volume when all logs have to be squared? But all logs have not to be squared; and where valuable timbers are concerned the true cubic contents have to be taken into account.

In Australia, in the cabinetmakers' shops they use up every scrap of their valuable timbers—Kauri, Blackwood, and Cedar. Again, as timber gets scarcer in New Zealand half-round sleepers may economically come into use, particularly in sidings and branch lines. They are used to a large extent on the Continent of Europe (not in England—they pack wastefully on board ship) and to some extent in Australia, particularly Queensland. (See "Australian Forestry," p. 295: Perth, 1916.) The half-round sapwood sleeper is the best for antiseptic treatment. I have not seen them in New Zealand.

In the huge limbs of Kauri there are large quantities of good figured furniture-wood, but in selling a tree it is very difficult to estimate that. Under wasteful methods of working and low prices it has been usually burnt. With higher prices for timber, and haulage on good roads, it is certain to be used (instead of wasted) in the future.

I am of opinion that the fairest way to sell trees is on the true cubic content of the bole with the crown thrown in. That is the practice with the New Zealand class of tree in South Africa. What the miller gets out of this will depend on markets and his own equipment and skill. Government milling, with its wide command of markets and good mill equipment, should be the most economical *under good management*, and I hope will be more largely followed in New Zealand. State sawmills should deal only with the true cubic content of a log and show what they get out of it, relegating the hoary Hoppus and quarter-girth measurement to what it really is—a trade trick, like the 14 oz. pot of jam!

Taper and Form-factors.—As above, the allowance for taper in Kauri is usually from 6 in. to 12 in. of girth per 20 ft. length of log; 12 in.

girth, or 4 in. diameter, per 20 ft. may be considered the recognized taper for trees having the form of Kauri "rickers." With a mean taper of 9 in. girth per 20 ft. the normal "Kauri tree of the future," 24 in. diameter under bark and 60 ft. bole, would cube 108 c. ft. gross. The same tree, taken without taper, would cube 188 c. ft. Thus one may say that the mean taper allowance for Kauri is $\frac{108}{188} = 0{\cdot}57$ per cent. of a tree without taper (the "ideal cylinder" of European forestry): 57 would be called the "form-factor" in forestry.

From this taper of 57 per cent. there are, in Kauri, all variations up to 90, 95, or even 100 per cent. for the old Kauri trees with practically cylindrical stems. The cubing of the historical record big Kauri tree of New Zealand in the Tutamoe Forest, near Waipoua, is described above (p. 42).

For trees in the "mixed forest" ordinary form-factors would run from about 55 to 65. In South Africa, as a liberal allowance to purchasers, and an allowance to include minor defects, there is a general all-round form-factor of 50.

Timber Units of Measurement.—From the above it will be seen that the forester's cubic foot of timber is equal to 12 of the miller's super. or board feet. But when it comes to comparing cubic feet in the log with superficial feet off the saw, 1 cubic foot is the equivalent of from 10 to 3 or 4 superficial feet, according to the waste in working: thus *1 c. ft. in the log* according to circumstances will equal—

	Sup. ft.
With Kauri, quarter-girth measurement, little taper, and rarely unsound, if well sawn	10
Average on squared logs, British sawmills, with 25 per cent. waste	9
Official average, United States of America, from log measurements in the forest to sawn output ...	6
In Australia, even after allowing for all apparent hollowness	6 to 4

The American "board foot" is the same as the Australasian superficial foot, but the ordinary American unit is 1,000 board feet instead of 100 superficial feet.

A convenient New Zealand unit is the "mil-sup." = a million superficial feet.

It is useful to remember that the price per 100 sup. ft. = $8\frac{1}{3}$ times the price per cubic foot. Thus, as a matter of buying and selling timber irrespective of what can be sawn out of it, the price, 8s. 4d. per 100 sup. ft. = 1s. per c. ft.

CONFUSION OF TERMS IN AUSTRALIA.

Popular writers on forestry frequently use the term "afforestation" and "reafforestation" when they mean nothing more than forestry. The confusion began in Australia, where, when the forest first came to be used and preserved, it was looked on as so extraordinary that they seized on the term "reafforestation" to express it; so that popularly, in Australia, "reafforestation" means the natural regeneration of the forest, not replanting with seed or young trees. In New Zealand the less said about reafforestation the better: it is meet to draw a veil over the "sins of the fathers!"

THE SILVICULTURAL SYSTEM.

Speaking broadly, Kauri forests are so valuable that *the object sought will be to bring them to full development in the shortest time.* They will have intensive management and "working-plans" similar to that sketched below ("Normal Kauri Forest," p. 83). This intensive management will be applicable wherever there is a first-grade forest with a fairly certain prospect of communication with a sufficient market during the next twenty years, or, with some modification in the "working-plans," during the next hundred years.

Distant forests, with no definite prospect of good communications, must have "working-plans" in which there will be *jardinage* ("selection") fellings, just to the extent warranted by local circumstances. The length of the rotation—whether *jardinage* and short, or *jardinage* and long (up to forty years as in India); or a "rotation of conversion" (as in South Africa) to the regular "shelter-wood compartment" system; whether regeneration is to be effected in groups, as in the Rhenish Black Forest, or with "strip fellings," as in the Swiss Alps—are technical questions which it would be out of place to discuss here. In my "Notes on the Management of a Normal Kauri Forest" below, I have gone into details sufficiently to show the economic position of the cultivated Kauri forests of the future, and how they would compare in population and profit with grazing and dairying; for apparently, without drawing up a balance-sheet, it has been assumed that dairying would give higher returns in money and more employment than cultivated Kauri forest. To make the following balance statement clear a few preliminary explanations are necessary.

JARDINAGE, OR SELECTION FELLINGS.

This consists in thinning out the mature trees from time to time as they are wanted. It sounds very little, but it means much, in keeping the fellings as regular as may be, and preventing the destruction of those parts of the forest that can be most easily reached. The regeneration may either be left entirely to nature or assisted just as much as the forest is worth the expenditure. Thus if a supply of White-pine were to be provided for, each old tree would be made to start a group of young trees before being removed. White-pine, on account of its lightness and shape of stem, could be easily got out of comparatively inaccessible forest. It will be recalled that most of the early working of the Kauri forest was in the form of "selection" fellings, by the Maoris, for spars and masts: usually, I am informed, these fellings were not followed by the destruction of the forest. In the old days there were camps of pit-sawyers (white men) dotted along the Wairoa River, the Maoris supplying them with Kauri spars and logs picked from the adjoining forest. Long spars and masts, 60 ft. and occasionally 80 ft. long, were culled from the forest in those days. Some of the heartwood cores of these old logs can still be seen to-day: and where the forest has been thus thinned but not destroyed it is regenerating itself naturally. If every other form of treatment were found to have disadvantages, there is always *jardinage* to fall back upon. It is so like nature that it cannot fail. There are several well-authenticated cases of regrowth and remilling the "mixed" forest in New Zealand.

"GROUP" SYSTEM.

Natural regeneration in New Zealand forests seems particularly adapted to what is known in forestry as the "group" method of regeneration, the *coupes par trouées* of French foresters. It is defined by the American Society of Foresters as "Removing groups of trees, making more or less irregular openings, and enlarging these until the entire stand is removed and regenerated" ("Journal of Forestry," Washington, January, 1917).

Says Sir William Schlich, writing in 1910 (Manual, vol. 3, p. 259), "The shelter-wood compartment system is followed over the greater part of the State forests of France and Germany, where natural regeneration is adopted, though there is evidence that it will in many cases be superseded by the 'group' or 'combined group and strip' system." The "group" system, he goes on to explain, is best for the regeneration of mixed uneven forests such as those of New Zealand. It is "specially adapted for the introduction of a more regular system of working into selection forests."

KAURI GROUPS.

Dr. Hochstetter, describing the Kauri forests as he saw them in 1867, nearly in their prime, noticed the tendency of Kauri to occur in even-aged groups. I have remarked the same thing, and it is a point to be stressed. These even-aged groups seem to have been caused—(1) When they are small, by the maturity and fall of a wide-spreading old giant tree, often bringing down other trees with it, and presenting in its tangled mass just that half-shade which is favourable to natural regeneration; (2) the larger even-aged groups are probably due to fires. The Kauri forest in ordinary weather is little liable to burn; but a fire lit during dry spells will burn off patches or strips, which afterwards, if there had been old Kauris in the burn, come up thick with young Kauris (pp. 118 and 146). Sometimes the charred stumps of old trees can be seen in the midst of these even-aged groups. The sample area we measured in the Waipoua Forest ("Waipoua Kauri Forest," p. 59) was, I should say, one such group. It was (for Kauri forest) well stocked, approximately even-aged, and with the remains of old burnt forest still showing.

STRIP-FELLING.

As far as circumstances will allow, the felling-areas should be laid out in the form of long narrow strips, the forest on the sides of each strip being left uncut till the regeneration of the strip is complete. This is the only way that any notable seedling regeneration (it coppices freely) of Stinkwood (*Ocotea bullata*), the most valuable tree in South Africa, has been obtained. Its planting is practically impossible, though the coppice seems to last indefinitely.

Strip-fellings are specially useful for the regeneration of trees with light seed, such as White-pine or Honeysuckle (*Knightia excelsa*), or where strong winds are to be feared; the strips, of course, being laid out across the track of the prevalent winds, so as to prevent the wind sweeping down the strip, and to favour seed being blown into the strip.

In Europe "strip-felling" has long been successfully practised in Alpine coniferous forest, where the westerly winds are as strong as in New Zealand. A well-known instance is that of the Sihlwald town forest of Zurich, Switzerland, where the strips are about the width of the tree-heights, and are simply wide roads cut through the forest.

Kauri best in Mixture.

Silviculturally, Kauri in New Zealand forests resembles Oak in European forests. Just as the European Oak does not flourish for any length of time as pure forest, but requires to be associated with some soil-improving species—almost always Beech—so Kauri, within my experience, is not seen at its best in pure forest. Kauri in pure (or practically pure) forest is short in the barrel and of slower growth than when mixed with Tawa and Taraire. These species are the Beech of Kauri. Both Tawa and Taraire are commonly associated with Kauri in the lower warmer parts of the Waipoua Forest: Tawa alone in the colder parts of Kauri's habitat. Tawa, I understand, was mixed with Kauri in the fine Kauri forests that formerly clothed the Waitakerei Hills, westward of Auckland City (where I first saw the Kauri forest), also at Thames.

Happily, Tawa and Taraire are strong seeders. Their dark-purple fruits strew the ground in autumn, scarcely to be distinguished from the familiar Olive fruits of southern Europe; so that the forester with his cultural operations has apparently an easy task before him—he has only to lighten the covert, and break up the often too-thick layer of humus on the forest-floor. The natural regeneration of Tawa and Taraire should be easier than that of Kauri, on account of the greater abundance of the seed and their less light-demanding temperament; and, as a fact, in the Waipoua Forest one sees ten or twenty seedlings and saplings of Tawa and Taraire to one of Kauri.

Deficiency of Young Trees.

It is an accepted fact that in both the Kauri forest and "mixed" forest the proportion of young timber and saplings is deficient. This was true in the original Kauri forest. It is truer still after so many Kauri spars have been picked out, as was the case with the old working in the Kauri forest. Colenso remarks (Trans. N.Z. Inst., 1868), "In a Kauri forest the proportion of spar trees to sawing trees is as 1 to 4 or 5." It is unfortunate that this should be so: it is one of the first faults that foresters will have to remedy in the cultivated forest. The reason for this fault is principally that the dense covert of the under-forest holds back the vegetation of timber-tree seedlings till an old timber-tree falls down and lets in enough light. With long-lived trees such as Kauri and many other New Zealand timbers, it is only at long intervals that these light-admissions to a seeded area occur in the wild forest. In the cultivated forest, with trees cut at intervals of 100 years, these light-admissions will be more frequent and young trees more abundant.

On the other hand, Celery-top (Tanekaha), a valuable quick-growing but not long-lived tree, often shows such a profusion of young regrowth that Kirk seriously proposed cutting saplings for walking-sticks as an export forest industry. ("Forest Flora.")

Felling in Season.

Practical timber-men lay great stress on felling in season. The right felling season for Kauri is discussed by J. C. Firth in a paper read before the Auckland Institute. He refers to the well-known shrinking of Kauri—a shrinking not only sideways, like most timber, but in length as well—and the brittleness and the decay of some of the Kauri timber. He says,—

> From long observation I am satisfied that there are only two months of the year in which Kauri, or indeed any trees in the North Island of New Zealand, can be cut down to prevent contraction and secure durability. These months are July and August, and of these months August is the best. (Trans. N.Z. Inst., 1874.)

Said Mr. James Burnett, Chief Engineer, Railways, to the Forest Commission (Report, p. 81):—

> Our Department has always tried to get the timber for its use felled during the winter-time, but we have never yet been able to succeed thoroughly in doing so. We are quite sure that the winter-felled timber is the best. The sap is then down, and the timber does not warp and split in the same way as timber felled at other times of the year does.

Other witnesses, all of them practical men, spoke in the same strain in giving evidence to the Forest Commission.

Says Blair in his useful paper on the "Building Materials of Otago," "All the Black-pine posts erected in the winter of 1861 are still in good preservation, while those felled and used a few months later were more or less decayed some years ago."

Says Laslet in his classical work on timbers, speaking of English Oak, "Winter-felled logs are sounder, less rent by shakes, and with less incipient decay at the centre."

Timber in Europe is nearly all felled in winter, but not quite always. In the Black Forest, where the forestry is of the best, timber is felled in summer and is held to be as good as winter-felled timber. ("Journal of a Forest Tour,", p. 17.) Professor S. J. Record, of Yale, says, "The amount of sap in a tree is fully as much, if not more, during the winter than in summer. Winter-felled wood is not drier than summer-felled; it is likely to be wetter." ("Mechanical Properties of Wood," p. 74.) This statement will not be readily accepted. My experiment made with Blue-gum in South Africa (*Eucalyptus globulus*), described in "Australian Forestry" (Perth, 1916), proves the contrary in the case of one tree; and most axemen used to cutting into trees in autumn and spring find the timber wetter in spring. In any case, timber felled in autumn and winter, seasons better than timber felled in spring and summer, for two reasons: (1) The sapwood dries more slowly; (2) the heartwood absorbs moisture at cut surfaces in winter, and thus tends afterwards to dry out more in harmony with the sapwood and so to split less.*

BORER IN KAURI.

Felling Kauri in early winter means that there may be an interval of nearly a year between the felling and the sawing, thus exposing the timber to some danger of the borer. In rare cases the borer will attack Kauri as soon as it is felled, and by four or five months this liability to the attack of the borer has to be seriously considered. However, means can be taken to entirely obviate this risk of borer, such as barking and brushing over with zinc solution, creosote, or other convenient antiseptic. In Europe barking after felling is the common practice. I am of opinion that the felling-period should be limited to late summer and early winter—say, May to July. That has been the practice in this class of forest in South Africa ever since they have had systematic forestry there. Captain Broun, in a paper read before the Auckland Institute (July, 1876), describes the beetle that does so much damage to Kauri as *Xenocnema spinipes*. The female beetle deposits her eggs under the bark, and in a very short time—a few weeks—the larvæ are boring into the sapwood. The common remedy for this in Europe is barking the timber shortly after it is felled. Captain Broun adds that fresh undecomposed resin is a complete protection against this borer, and that its habitat is the Kauri forest, only stray individuals being seen away from it. Another borer, *Dryoptherus bi-tuberculatus*, completely riddles the dead sapwood, which it attacks whether the bark is on or off the tree.

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* Heartwood, when complete, is dead tissue, and theoretically should hold no more moisture than air-seasoned cut timber. (See also "Australian Forestry, pp. 95, 222, 231.) It is understood that the Victorian Forest Department is now conducting an investigation of the subject as regards Eucalypts.

A Real Growth-stoppage in Winter.

This, however, is worth noticing. The rings of growth on New Zealand Fuchsia (*Fuchsia excortica*) indicate indirectly the reality of the growth-stoppage in the dead season, and the importance of felling timber then. Fuchsia, in middle latitudes of New Zealand, is practically quite leafless during winter, but its annual rings of growth are no more distinct than the ordinary evergreen trees which do not shed their leaves. We know that there can be no active growth on such trees as Fuchsia and Lacebark, which during the New Zealand winter are as leafless as Northern Hemisphere "leaf-wood" trees. It follows that if Fuchsia has rings less distinct than the ordinary evergreen trees of New Zealand, these are making no more winter growth than the leafless Fuchsia; so that there is a really dormant season even for the evergreen forest-tree of New Zealand.

Low Stock in Wild Forests: Auckland's Future Kauri.

In the present wild forests the "stand" (bulk of milling-timber per acre) averages very low, if one considers Kauri alone, though it is considerably better than the average of Teak in the Teak forests of India. It remains now to improve the Kauri forest by silvicultural methods, as the Indian Teak forests have been gradually improved during the last fifty years. Kirk, in his "Forest Flora," estimates the stand of Kauri as varying from 250 to 6,000 c. ft. He says, "For good Kauri forest 20,000 sup. ft. per acre would be a low estimate." Let us say, then, 2,000 c. ft. of milled timber as a fair estimate for good Kauri forest, or 2,700 c. ft. log-measurement, adding one-third for sawing loss and the wasteful working methods of 1888, when Kirk wrote. If we assume 200 years as the *average* cutting-age of Kauri (and it is less rather than more, taking the ordinary size of Kauri logs) one has 2,700 c. ft. ÷ 200 years = 13·5 c. ft. as the acrim (mean yearly growth in cubic feet per acre). This figure works out so low for two reasons: (1) It refers to a wild and only partially stocked forest; (2) the trees are about double the age and size of their economic maturity.

Cultivated Kauri Forest Eight Times the Wild.—Thus, taking these figures, the cultivated forest with an acrim of at least 100 would be some eight times as productive. Or, in other words, cultivated forest of but moderate capacity on one-eighth of the area of the old virgin forest would bring back the Kauri timber industry to what it was at its best.

The Auckland timber industry may have not yet seen its best days, nor the Kauri-gum industry its most lucrative ones!

Auckland has probably never had more than some 2,000,000 acres of Kauri forest to draw on (p. 6), and has wasted more than half the timber in the working. Thus the half-million acres of cultivated Kauri forest discussed at page 4 would give Auckland and the Kauri-timber industry some four times the supply in perpetuity that it had temporarily in the best of the old days.

THE NORMAL CULTIVATED KAURI FOREST.

FROM REGENERATION TO THE FELLING OF THE MAIN CROP.

Density of a Kauri Forest.

IN ordinary Kauri forest there may be seen small patches of five or six trees—"Kauri trees of the future"—with diameters not much above 2 ft., standing at about 8 ft. apart. These spread out above the lower story of forest and get the space which the Kauri (silviculturally a light-demander) requires. The lower story, of Tawa, Taraire, &c., will grow just as close, also often in patches. But between these patches, over perhaps three-quarters of the area, there will be nothing but useless undergrowth. One can perfectly reasonably suppose a stocking, at age 100 years, with trees averaging 12 ft. apart, or 302 trees per acre, of which 150 trees might be Kauri and 150 trees Totara, Rimu, White-pine, Taraire, Tawa, and inferior species; or such larger proportion of Kauri as silviculturally the forester may find correct.

Number of Kauri Trees required at Regeneration.

If there were an average of 200 Kauri standards per acre at regeneration, one could count on 150 surviving at age 100 years. Thus the "working-plan" should require a minimum of 200 young Kauri trees before considering regeneration complete, planting where necessary to make up the 200; and for the inferior species perhaps as many as could be got without incurring the expense of planting. Where this number was less than 100 the planting of Rimu, Totara, Puriri, Celery-top, White-pine, and perhaps Tawa or Taraire, to make up the 100 could be prescribed. Of these species, Rimu might give some trouble to plant (though it did not on a small scale in South Africa), while the rest would be easy. 150 stems of the "Kauri tree of the future" (p. 74) would cube 118 c. ft. × 150 = 17,700 c. ft. (gross cubage in the round), while the yearly yield-figure (acrim) of 100 c. ft. q.g. assumed (p. 98) requires only 12,500 c. ft.* to be provided for. It will be asked why is there so large a margin between 12,500 c. ft. estimated yield, while the trees, if they all matured, should give 17,700 c. ft. of Kauri and about half that of secondary species, or some 26,550 ft. altogether? The answer is that though these trees would be in the position of standards in their youth, as they grew up they would gradually get into the positions of high forest, when the weaker ones, the badly grown ones, and the inferior species would go out in thinnings. It is the Kauri reserves (p. 86), and these thinnings towards the end of the first rotation of 100 years, which have to be depended upon to make up the average acrim of 15 c. ft. q.g. of Kauri and 20 c. ft. q.g. of other timbers (p. 96, "Balance Statement").

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* 12,500 c. ft. = 10,000 cubic feet quarter-girth, which is the normal "stand" at the end of 100 years.

Summary of Stocking per Acre.

Thus the number of trees provided for at regeneration—Kauri, 200; other species, 100—will, as far as rates of growth are known, yield—

	C. ft.
Gross measurement in the round log per acre (as above)	26,550
Yield assumed	12,500
Margin of safety if all trees matured	14,050

Though the final crop will contain some particularly well-grown and well-placed trees of other species, I shall relegate these to the margin required in all estimates and assume for the final yield 10,000 c. ft. q.g. of Kauri in 107·5 trees of 93 c. ft. each (quarter-girth measurement)—the Kauri tree of the future cubing 118 c. ft. in the round and 93 c. ft. q.g. In even numbers, we may say that 100 Kauri trees of 100 c. ft. q.g. each, cut at 100 years of age, will furnish an acrim of 100 c. ft. It is one of the vagaries of figures that they should run out thus. It makes them easy to remember (p. 180). It will be useful to compare these 100 Kauri trees, yielding 100 c. ft. q.g. each at the end of 100 years, and thus making up a timber stand of 10,000 c. ft., with similar figures elsewhere. In New Zealand we have 8,233 c. ft. q.g., the best stand that has ever been realized in the wild forest, and that only over small areas. (Lands Department, 1909: Special Rep. on Forestry.)

European Trees like Kauri: Silvicultural Data.

In European forests, turning to Schlich's Yield Tables, one sees that as regards rate of growth the nearest tree to Kauri seems to be first-class Oak. This has about two-thirds the growth of Kauri, and so at age 160 years corresponds approximately to Kauri at 100 years. At 160 years first-class Oak averages 23½ in. in diameter and 117 ft. total height of tree. But Oak at that age grows sparse, and is usually underplanted with Beech or some soil-improving species, so that the average number of stems per acre at that age is only 56.

Another European tree that resembles Kauri in growth, except in slower diameter-growth, is first-class Spruce. At 100 years this averages 15·2 in. in diameter and 104 ft. total height, and has 220 trees to the acre; while the shade-bearing Silver-fir, which at 50 years averaged 270 more trees to the acre than Spruce at age 100 years, averages only 200. First-class Spruce at 100 years has a stand of 14,250 c. ft. in the round, and Silver-fir of 14,290 c. ft. in the round; in addition, each of these has yielded about one-third of these figures in thinnings.

STANDS OF TIMBER.

New Zealand Millable twice Appalachians.—Certain "stands" of timber are quoted above (p. 64) in connection with the stocking of the Puhipuhi Forest. The following table merits careful perusal. It shows that the present New Zealand millable forest, even in its wild state, has twice the average timber stand of the Appalachians forest, U.S.A., about which so much has been written, and for which so much paid.

The first two stands of timber on the list below (New Zealand and Appalachians) are wild forest over large areas. Such forest, with timber of all ages intermixed, and with irregularity in the stocking, has generally a much lower average stand of timber than the cultivated forest. Dr. Somerville gave a detailed account of his forest tour through the Appalachians in the English *Quarterly Journal of Forestry* for March, 1910.

Various Stands of Timber: Cubic Feet per Acre.

	C. ft.
The Appalachians forest is being redeemed for the nation, at the cost of millions, by a special Act of Congress. It is the greatest forest redemption in the world's history. In his letter to Congress President Roosevelt describes it as "the heaviest and most beautiful hardwood forest of the Continent." The "average best stand of timber over large areas" seen by Dr. Somerville in his tour of 1909 was ...	1,400
The average millable forest of New Zealand carries about double the timber stand of the Appalachians (Lands Dept. Forestry Rep. 1915–16). Thus the figure generally accepted for many years in New Zealand is 15,000 sup. ft. of mill output. At the official U.S.A. conversion figure this would represent 15,000 ÷ 6 = 2,500 c. ft. With the unchecked waste of past forest-working in New Zealand the "stand" corresponding to 15,000 sup. ft. "off the saw" must be taken as being at least equal to	**3,000**
Average timber stand for the five chief timbers of mid-Europe—Oak, Spruce, Silver-fir, Scotch-pine, Beech—at 90 years of age in forest cultivated for over 100 years, viz.:—	
First-quality forest (Weise's Yield Tables)	9,550
Second- or medium-quality forest	6,332
Third- or lowest-quality forest (the shade-bearing Silver-fir being the only species that does not show a great decline. The general average may be taken as being about the same as in the New Zealand wild forest of millable quality) ...	3,650
Larch at 60 years, Tintern, England, the best in the Forest of Dean and probably in England (all planted)	6,000
Oak at 100 years, Forest of Dean, England, maximum group ...	11,957
Oak at 100 years, first quality, average mid-Europe (Veise) ...	7,800
Normal Kauri forest (when cultivated), 10,000 c. ft. q.g. assumed (for gross volume adding one-quarter)	12,500
Spessart, Rhineland Oak, and Beech (some Oak cut at 300 years)	12,500
Maximum stand Silver-fir, Black Forest	14,500
Silver-fir near Copenhagen, Denmark (a small area)	19,000
Totara, small areas in Rai Valley (Marlborough) and Pahiatua, 200,000 sup. ft. (W. B. Buckhurst). At 1 c. ft. = 6 sawn sup. ft. this equals	**33,333**
Douglas-fir, maximum best-stocked areas, North America ...	50,000

(For stands of timber in Australian forests see pages 103 to 107 of "Australian Forestry"; for some more American "stands," p. 157.)

THE 100-YEARS TRANSITION PERIOD.

The Old Timber of the Virgin Forest.

It has been seen (p. 68, "Puhipuhi Forest") that where there is enough young timber to get age-classes and a regular yield at once the forest has a greatly enhanced value—some £700 per acre. That is, however, a rare case in the Kauri forests of New Zealand. Commonly a "transition period" of about 100 years is necessary before the Kauri forest becomes fully stocked with young timber, middle-aged timber, and mature timber.

The first consideration is the gradual working-out of the old overmature and ripe timber of the virgin forest. Just how long it will take to cut out this old overmature timber of the virgin forest in each case is a matter of public convenience. I understand that the Government wish to keep a certain supply of Kauri in hand. This could be done in properly constituted forest reserves without incurring all the loss mentioned at Waipoua ("Waipoua Kauri Forest," p. 27) in having a virgin forest earning nothing. From a silvicultural point of view, the slower the virgin timber is worked off the better for the age-classes in the forest afterwards, though as Kauri grows rapidly from age 100 to age 160 or 180 there might be little loss during the next rotation in letting the requisite quantity of Kauri run on towards this age in order to rectify the age-classes. That will be a matter for the Forest Department to advise about, and the Government to decide on, 120 years hence—the happy time of a Kauri timber surplus. For the present I take it that all the old virgin-forest timber will be worked off between 10 and 30 years from now. I therefore take 20 years as a mean period.

The younger portion of the Kauri trees in the virgin forest will be left uncut to form a Kauri reserve, as appears below. (See Plate XII.)

When the old timber of the virgin forest has been worked through all that part of the forest will be restocked with young timber, and it will be 100 years before that young timber is fit to cut. This may be called the "transition period," since the forest during the whole of that period will be getting gradually converted from an all-aged, irregularly-stocked wild forest to an even-aged, fully-stocked, cultivated forest.

After the 20 years allowed for the cutting-over and restocking of the overmature virign forest (Kauri at Waipoua, for instance), the cutting-over and restocking of the rest of the forest will then be taken in hand. The slower this is done the better for the age-classes, but the worse for the forest as a money-earning estate. One may perhaps allow another 20 years for this, thus bringing one to the cutting-period of the Kauri reserves some 40 or 50 years hence.

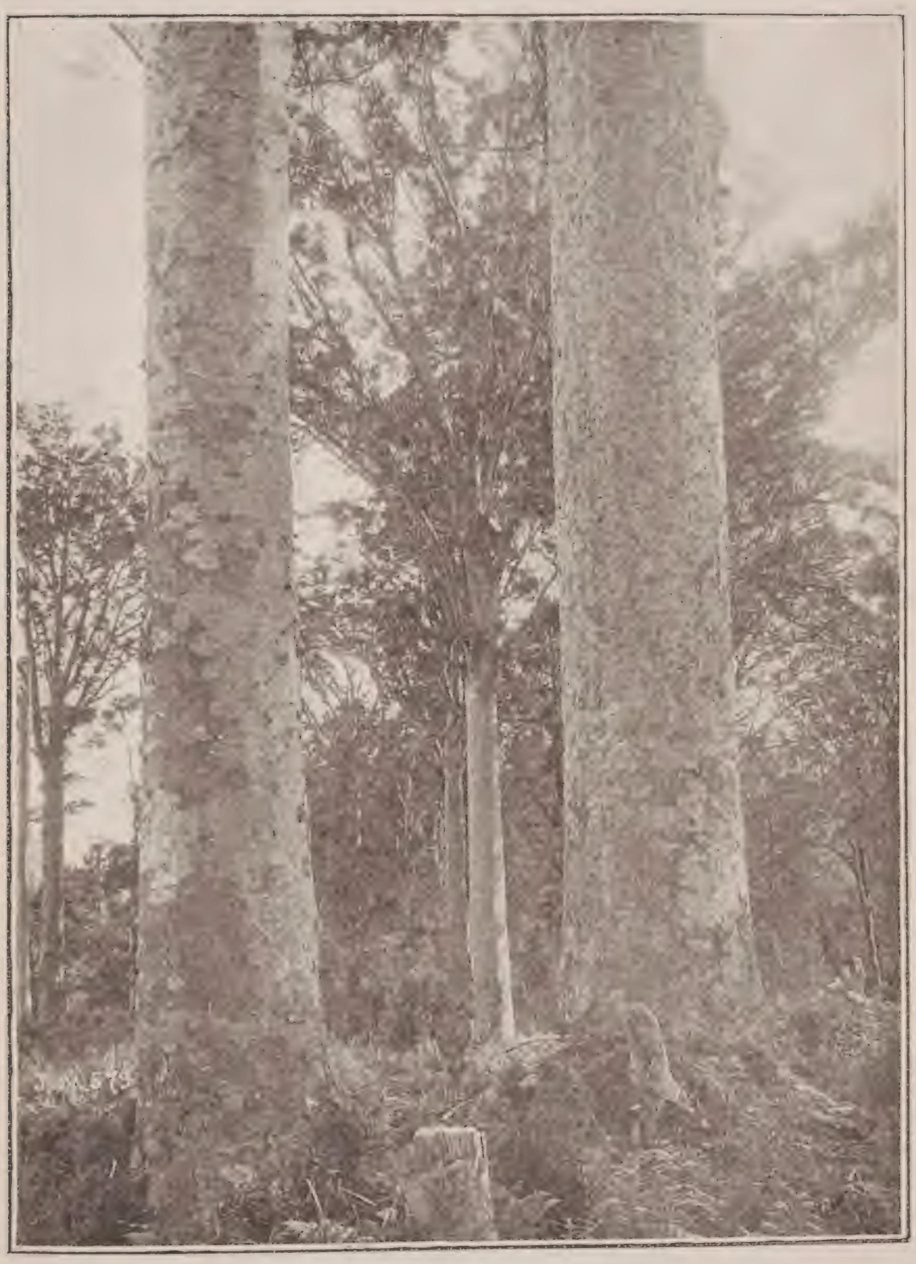
THE MID-ROTATION KAURI RESERVES.

When cutting out the old virgin-forest timber there would naturally be left such trees as were necessary for silvicultural reasons, especially seed and soil-shelter. Such trees would first help to seed their own ground, and then be available for the seed-supplies of the Forest Department. A forester everywhere tries to keep the soil covered as far as may be. Further, he would consider the reservation of *all the younger trees whose growth might be expected to pay, or nearly pay, interest on their present money value.* Looking at the steady rise in the value of Kauri, it may be anticipated that there would be many such trees: silviculturally, and for the age-classes, the more the better. For Government purposes a supply of Kauri timber that could be looked forward to with certainty in 40 or 50 years might be very useful—in the Railway Department, for instance.

Cultural considerations, the state of the young Kauri or Totara in each group, would determine the final early or late removal of these reserved trees.

It is the Kauri reserves, and the thinnings towards the end of the hundred-year "transition" period, that will make up the mean yield of 15 c. ft. per acre per year entered in the "Balance Statement" below.

PLATE XII.



THINNING THE KAURI FOREST.

Fine Kauri forest at Kaihu. This has been destroyed instead of being thinned and preserved. The clean stems with the dead bark being perpetually shed are well shown here.

Photo, J. Martin.]

[*To face p. 86.*

As indicated at p. 84, the stocking here provided for leaves a wide margin for casualties and thinnings—indeed, more than the whole stand estimated for at the end of the rotation. These thinnings will be in the last quarter of the rotation, at a time when they will be remunerative.

Damage to Natural Regeneration in Logging.

It will, I know, be objected that the extraction of these trees at a mid-rotation time would do much mischief to a young half-grown forest, but that is more a popular than a forester's objection. These Kauri reserved trees would not be old Kauris, with their huge crowns, smashing flat everything in their fall over a wide area, and with logs having much the form of an exaggerated garden-roller, requiring to be jacked out along the line of least resistance and crushing everything in their course. They would be well-matured Kauri "rickers," such as are removed in ordinary forestry-thinning operations the world through. It is easy to fell such trees just where their fall will do little damage and to haul them out afterwards, each log over the same "slip-path," with only narrow lanes in the forest, which in a few years will be entirely overgrown, and often with the best timber-trees.

Even hauling logs over natural regeneration does less damage than appears. Nearly all forest seedlings, though crushed and broken, will shoot up again, provided the damage be not too long continued. In the Swiss Sihlwald forest, "the model forest of Europe" as it has been called, they make plantations under Beech forest and in three or four years remove the old Beech. The official allowance for damage done in removing the old Beech is 1 per cent. ("Journal of a Forest Tour," p. 90.)

In all the old fuel copses of Europe that have been cut over every ten or twenty years for a century or two the trees shoot again freely. Men, horses, and wagons pass everywhere as they want to. Provided the trampling is not repeated the trees shoot up again freely.

The steep mountain grounds of New Zealand lend themselves to economical timber-transport by cableway. It is reported (Lands Department, 1916–17) that a Lidgerwood cableway has already been installed by the Marlborough Timber Company of Southland. This would obviate all injury to young trees on the ground.

Lastly, one must remember the unique chance for economical interplanting offered by hauling-roads and slip-paths. My feeling is that as soon as New Zealand forests come under systematic working the cry will be for more and still more of such fine planting-tracks!

Kauri Thinnings.

The thinnings in a mixed Kauri forest would bear mostly on the secondary species. Excepting quite the later thinnings of Kauri, the others (for impregnated half-round sleepers and fencing-posts) might not do much more than pay costs.

It has to be remembered that in this improved forest—of Kauri, of secondary species, and of underwood—the first change to notice will be the suppression of the underwood. The forest will become a "clean bush" such as it is to-day (alas for the traveller!) only in places where there are patches of pure forest of Tawa or Taraire and more rarely of Kauri, for that has a covert inferior to Tawa and Taraire. In many places the suppression of the troublesome underwood may allow the tall forest to grow to a hundred years with but little thinning.

A Thirty or Forty Years' Interval for the Miller.—There will be little thinning till about the period of the mid-rotation, which means that when an area is milled now there will be taken out from that forest all the timber fit to cut for the next thirty or forty years. (See "Conservative Lumbering.") Of course, here it is the forester who judges what trees are fit to cut, and he, in marking the trees for felling, has to keep one eye on the future of the forest and the other eye on the requirements of the sawmills. Naturally, experience and judgment are required in marking a *coupe* or cutting-area. Usually the superior forest officer himself checks personally some 10 per cent. of the timber-marking. I have had many days doing this—days that were long and weary at the time, but pleasant in their after-memories.

PRACTICAL WORKING OF THE "BUSH" IN SOUTH AFRICA.

The following is a popular account of the marking of the timber for felling in a South African forest (Knysna) where the climate and forest are almost exactly like those of northern New Zealand. It was written by myself (part of a popular lecture) when in charge of these Knysna forests, and has been preserved in the official publication, Sim's "Forest Flora of Cape Colony," p. 67 (Lands Department Forest Library, at Wellington). These Knysna forests are far from being in as good a condition as Waipoua. They were worked heavily for some fifty years before the advent of a Forest Department in 1883, and destroyed or degraded. Forest-work began there as far back as 1782. They have one timber as valuable as Kauri—"Stinkwood"—but that is getting yearly scarcer, and was never as abundant as Kauri at Waipoua.

To understand the following extract it should perhaps be explained that the Knysna forests are worked by *jardinage* or "selection" fellings with a rotation of forty years, for a time shortened to twenty years. Of course, at the end of the rotation the series of fellings comes round to where they started. These *jardinage* fellings at Knysna are intended to be a step in the conversion of the wild forest to the normal forest, consisting of *even-aged compartments* which in number will be equal to the number of years in the final rotation. The experience of thirty years has clearly shown that it would have been better in South Africa to have adopted the final or normal rotation from the start, and to have put each compartment ("section") into complete order at the cutting of the virgin forest or what stands for it. The scheme here drafted for the Kauri forest is *for conversion of the wild forest to the normal forest in one rotation* (pp. 82 and 95.)

The Knysna forests are logged entirely by millers and license-holders, not by Government. The system has faults, but is, on the whole, more economical than Government working. France has this same private logging; Germany and Japan, Government logging. Australia has recently introduced conjoint logging—viz., private and Government working side by side. Thus the working of each can always be compared. The matter is largely one of public policy, and I shall revert to it under the chapter on "Forest Policy" in Part II.

The hauling at Knysna is all done by cattle. This is undoubtedly the best system where the timber is scattered, and especially where the oxen and "bullockies" are so good as they are at Knysna. (See p. 42. "Waipoua Kauri Forest.") It has been mentioned (p. 87) that the log-hauling tracks, whether steam-haulers, cattle, or horses are used.

do no permanent harm to the forest—rather the reverse. They certainly lower considerably the cost of interplanting.

We foresters claim—and it is a claim that any one can satisfy himself about by taking a walk through the forests—we claim to be using and at the same time improving the forests in our charge.

The forests at Knysna, and along the Amatolas, are managed on this system. The larger forests are divided up, and the small forests grouped together into a working unit called the "series." In the Knysna Conservancy there are thirteen "series" with an average of about 4,000 acres each.

One of the "series" in the Knysna Conservancy—that nearest George—has been so much overworked in the past that it has been entirely closed for the present. So there are now open and being worked at Knysna twelve forest "sections" or compartments averaging 100 acres each. Each year in each "series" a fresh "section" is opened. It will thus take forty years to work through each "series," and at the end of that time the "sections" first opened for working in 1883 will again have mature wood grown up in them. You will understand that when a forest section is worked not all the trees are cut down, but only those that are mature. Who is to judge what trees are mature? In this lies the pith of the whole matter.

If you leave the judging to the woodcutter, as in the old days, he will very naturally judge those trees mature which suit his own convenience. He will pick out the best trees, and leave the worst to grow and form the forest of the future; he will overwork and destroy the accessible forest, and leave mature timber to rot in the inaccessible forest. To avoid these evils each forest section, before being thrown open to the public, is thoroughly and closely examined by the Forest Department. Every tree in the section is inspected, and those which, *looking at the future of the forest*, should now be felled are numbered, measured, and entered in a book kept for the purposes. This is a long and tedious business, and occupies the conservator and foresters for several months. We are always glad when it is over. It is pleasant to walk through a marked section. At about every hundred yards (the distance depends on the density of the forest) lines termed *virèes* have been cut to guide the workers. As one walks down these lines, or along an old slip-path, or occasionally along an elephant-path, the trees marked for felling come into view. Each of these doomed trees carries a large cross in red paint high on its trunk; at its foot, half-buried in fern and beautiful foliage, is a number, also in paint; and below all, probably on a gnarled root, is the Government stamp. With a little practice you will be able to see why each tree marked for felling has been selected. Here is a hoary old giant of several centuries' growth. His massive limbs were flung out very much as they now are when the white man first came to the country; his bole runs up straight and cylindrical for forty or fifty feet like the columns in the aisle of a cathedral. No one cared to tackle him under the free-selection system. He may be still good timber, or he may be a mere rotten shell and too rotten already to work with profit. It is easy to see why *he* has been marked for felling! By his side stands a slender stripling. We wonder why *this* has been marked for felling. Surely it will be worth much more in forty years! But it bears the fatal red cross; and we look again. There on the other side of the trunk is a black streak; higher up a decayed branch. That tree is rotten at the heart. It must be cut down to make room for a sound tree. Whatever value it has is in the present. In marking the trees for felling in a forest section this is the principle followed: *Unless there are cultural reasons to the contrary, every tree is marked for the axe that will not in forty years increase in value more than its present value put out at interest at 4 per cent.*

Not to detain you too long, I must touch very briefly on forest culture, or what is termed silviculture. Before a tree is marked for felling one has to look on the ground and look around to see what there is to replace it. No forester, if he can help it, makes a large gap in the forest. A gap in the forest is a dangerous thing: it lets in wind and sun. Wind may blow down the surrounding trees; sun is more to be feared—it deteriorates the forest soil, induces a growth of grass and inflammable herbage. A sudden exposure to sun will kill the seedlings of forest-trees. Stinkwood is especially tender in this respect. So you see that when a forester plods down the *virèe* lines day after day marking the trees that are to be felled next year, he has plenty to think about, plenty to do; and when each year's section of forest has been completely examined the most

> arduous part of his duties for that year are over. His work is checked by his superior officer, the Conservator, who, book in hand, checks 10 per cent. of all his measurements and criticizes his selection of trees for felling.
>
> Everything being now ready, the forest sections are thrown open to the public on the 1st March in each year. The forest remains open for felling till the following June. All timber has to be worked and got out of the forest by the end of December; 15,000 trees on an average are thus felled yearly in the Kynsna Conservancy. The average size of the timber from these trees varies according to the quality of the forest. In the Gouna forest, near the port of Knysna, where it is almost virgin forest, the average of the trees felled is 56 cubic feet each. In the poor forests near George and Plettenberg Bay, in forest that has been overworked and irregularly worked for fifty years, this figure falls from 56 cubic feet per tree to only 12 cubic feet, and to as low as 8 cubic feet at Wit Els, the end of the forest country towards Humansdorp.
>
> Each section remains open for two or three years. It is then put in order by the Forest Department and closed for forty years. Planting and thinning, more or less, according to circumstances, are required to put a section in order.

The photo opposite (Plate XIII) shows logging in the mountain forests of the east of the Cape Province near King William's Town, the first forests demarcated in South Africa. They were demarcated in 1884, and have been worked since, the mature timber, as marked by the Forest Department, being taken out. These forests are of the same character as the "mixed forest" of New Zealand, and in a New-Zealand-like climate—rainfall about 60 in., with three or four snowfalls each winter. An accompanying photo (not reproduced) shows the logs coming down a timber chute.

For an excellent short account of forestry in South Africa the reader may be referred to the American periodical, *Forestry Quarterly* for December, 1916. The writer, H. R. MacMillan (late Chief Forester, British Columbia), visited South Africa in 1916. He says,—

> South Africa, of all British dominions, and one might say of all English-speaking countries, lost least time, after the first important settlement, in considering forestry. . . . South Africa, with only a fraction of the population and resources and a very much less interest at stake, has faced the problem of forest organization in a more statesmanlike manner than has any part of Canada, and as a result is building in a more permanent manner and on a sounder basis.

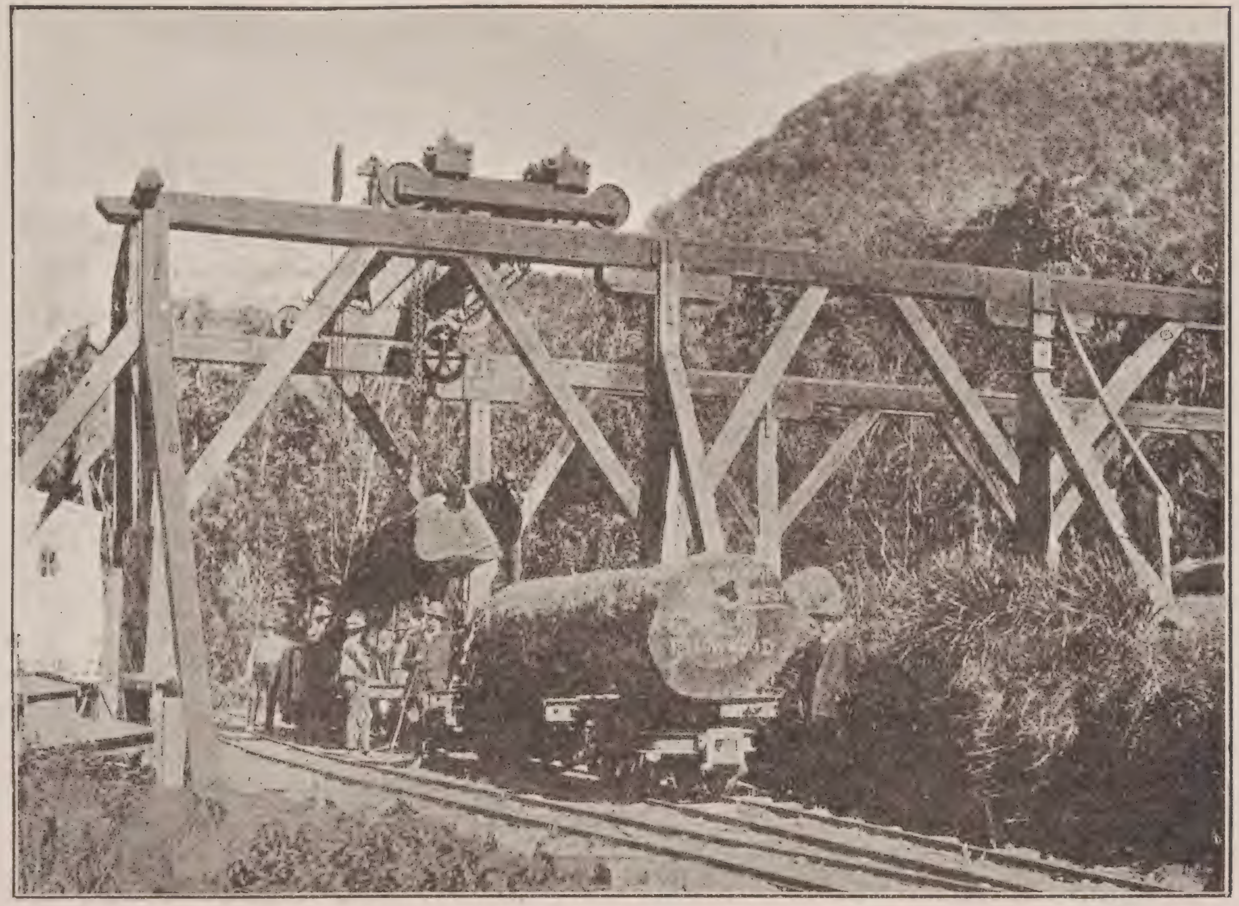
This year (1918–19) South Africa is spending £194,000 on forestry.

FOREST-WORKING IN THE UNITED STATES OF AMERICA: MARKING TREES FOR FELLING.

In the national forests, where the forests are worked by the Forest Department, trees to be felled are previously inspected and marked by a forester. The process is thus described by a recent writer in the organ of the American Forestry Association:—

> In accordance with a previously prepared working-plan the officers who do the marking go through the stand selecting for cutting those trees which are mature or overmature, and those immature ones which are in some respects defective or which need to be removed to thin crowded groups, so that those left in the group may have room to grow and develop properly. All the young and middle-aged trees which are sound and thrifty are left, and they will greatly increase in size and value before the next cuttings on that area. . . . Furthermore—and this is a vitally important thing—the removal of the diseased overmature trees has eliminated a vast amount of fungus disease, and materially decreased the opportunity for infection of healthy trees, so that the stand has not only been put in much healthier condition, but it has much better chances of remaining healthy. ("American Forestry," May, 1917.)

PLATE XIII.



LOGGING IN THE MOUNTAIN FORESTS NEAR KING WILLIAM'S TOWN, SOUTH AFRICA.

The logs are *Podocarpus elongata*, going to over 11 ft. diameter, maximum size.

[To face p. 90

The Forest Commission of the State of Maine, U.S.A., sketches thus the forestry procedure in the national forests :—

> A trained forester is in charge as a supervisor, and Forest Rangers are employed. Tree-planting is practised where natural reproduction is not sufficient. Sales of timber are made under strict regulations. All trees to be removed are marked by a forest officer; and 12 in. in diameter, breast-high, is as small as soft timber may be cut. On account of the care given to them the forest lands become of great advantage to the State.—(F. H. COLBY.)

For the official instruction in marking a mixed forest of *Pinus ponderosa*, Douglas-fir, &c., in Oregon, see p. 122.

It might be thought that marking and measuring timber before felling would be a costly operation. This is not so. The rapidity with which a bushman in New Zealand gets about and recognizes the timber-trees is unsurpassed. In the Auckland District, where timber has been marked and measured before felling for some years, the average cost works out to almost exactly 1d. per 100 sup. ft.—say, 0·1d. per cubic foot.

THE TIMBER-YIELD AND REVENUE OF THE FOREST.

ACRIM OR TIMBER-GROWTH FIGURE.

Taking the forest through, there will be trees of all ages, either (1) mixed up together, as in the wild forest or *jardinage* forest, or (2) with the ages more or less graduated in separate compartments, as in the normal forest; and there will be a yield-figure (acrim) representing the bulk of timber laid on yearly, which will gradually rise, reach a maximum in probably about eighty years (see published Yield Tables), and then gradually fall. Neglected thinnings would make it fall sooner and more rapidly. Then there is the acrim from two points of view: (1) The average acrim, taking in the whole age of the forest, and (2) the current acrim for short periods. Further, the acrim may be for the whole tree, or for the timber only. As soon as New Zealand gets town forests, or other accessible forests, it will be for the whole tree, but at present the yield-figure for the whole tree has no practical significance. Here and elsewhere in this report I consider only the bole of the tree and the *average timber acrim*—viz., the average timber increment per acre per year taken, unless otherwise stated, up to the cutting-period. This is near enough for a general discussion, and the corresponding current acrim or other acrim can easily be approximated from any of the published Yield Tables for forest with corresponding factors. The average timber acrim is shown in Schlich's tables as "Total yield, solid cubic feet, timber only, mean annual increment" (column S, p. 375, &c., vol. 3, of Schlich's Manual).

The average timber acrim here assumed for the normal Kauri forest of the future is 100 c. ft. q.g. of Kauri and 40 of other timbers, rising gradually as the forest improves to 200 c. ft. q.g. of Kauri (p. 101). The moderation of these figures will be seen by referring to the general Table of Acrims given in the statistical appendix. It will be noted also that a rough calculation made the Puhipuhi acrim about 175 c. ft. q.g. of Kauri (p. 63). Acrims are discussed in "Australian Forestry" at pp. 123 and 401.

Three general acrims may be mentioned here :—

(1.) 95, the general figure for the whole State of Baden—practically the Black Forest. The soil here is poor, the climate rigorous; in fact, the tree-growing period averages some five months against about eight months in mid New Zealand.

(2.) Dr.* Henry, the premier English tree expert, describing the possibilities of the "New Forestry in the British Isles" (Scotch-pine being replaced by better trees), estimated a general all-round acrim of 200.

(3.) It has been announced that Jarrah, a tree growing so slowly that it cannot be profitably planted, will have at eighty years a stand of 8,000 c. ft. in cultivated Jarrah forest. (Forest Bill, Westralia; second-reading speech by Hon. R. T. Robinson.) This means an acrim the same as my estimated Kauri acrim—viz., 100 c. ft.

In the plan for a normal Kauri forest sketched here the acrim, it is evident, will be low till the better growth produced by the foresters' regeneration methods have taken effect, and the revenue will not be benefited till that timber is fit to cut. I will assume that a few years after regeneration there will be an acrim of 100 c. ft., and that this acrim will spread gradually over the whole forest as the present crop of timber is cut and the forest regenerated. It will be 100 years before the first of the regenerated Kauri is fit to cut; and if twenty years be taken to work through and regenerate the old virgin-forest timber, it will be 120 years from now before the improved regrowth forest is all fit to cut. In the meantime the fellings and revenue will only be from thinnings and from the mid-rotation Kauri reserved trees left over when cutting out the old timber of the virgin forest mentioned above. Then, from 100 years the revenue will be rising rapidly as the first of the improved forest matures.

As mentioned above, I assume for the normal Kauri forest, after the virgin-forest timber is cut, and during the 100 years of the "transition period" that must elapse before the regrowth timber matures, an average yield of 35 c. ft. q.g. of millable timber per acre per year—15 Kauri and 20 other. After that, 100 c. ft. q.g. Kauri per acre per year of millable timber. This 100 c. ft. q.g. is the normal yield. It will never be less than 100 and may rise gradually to 200.

During the 100 years of the "transition period" there will be less than 35 c. ft. q.g. to cut at first, more afterwards.

Forty Lean Years, with Fat Years at the End.

The 35 c. ft. acrim will be made up at first of light thinnings among the secondary species and some deferred regeneration fellings of the Kauri virgin forest. These at first will yield nothing like the 35 c. ft. per acre per year, the average yield estimated for the whole period. This, in fact, will be the lean period in the working of every Kauri forest, just as seventy or a hundred years later there will be a fat period with a plethora of mature Kauri. It will be the business of the "working-plans" forest officer to so anticipate and defer fellings that the yield will be more equalized, and with it, of course, the distribution of the age-classes. He can help the lean years by running some of the virgin-forest fellings into them; he can help the plethora years by anticipating or deferring the felling of the 100-years rotation; and in doing this he is helped by nature, for that is the time when Kauri is growing rapidly and holding up its acrim against any rapid decline. In other words, there will be large supplies of Kauri timber on hand, and it will depend on the timber-market and on Government demands whether the timber is harvested twenty years sooner or forty years later. What the forester will be looking at will be a good distribution of age-

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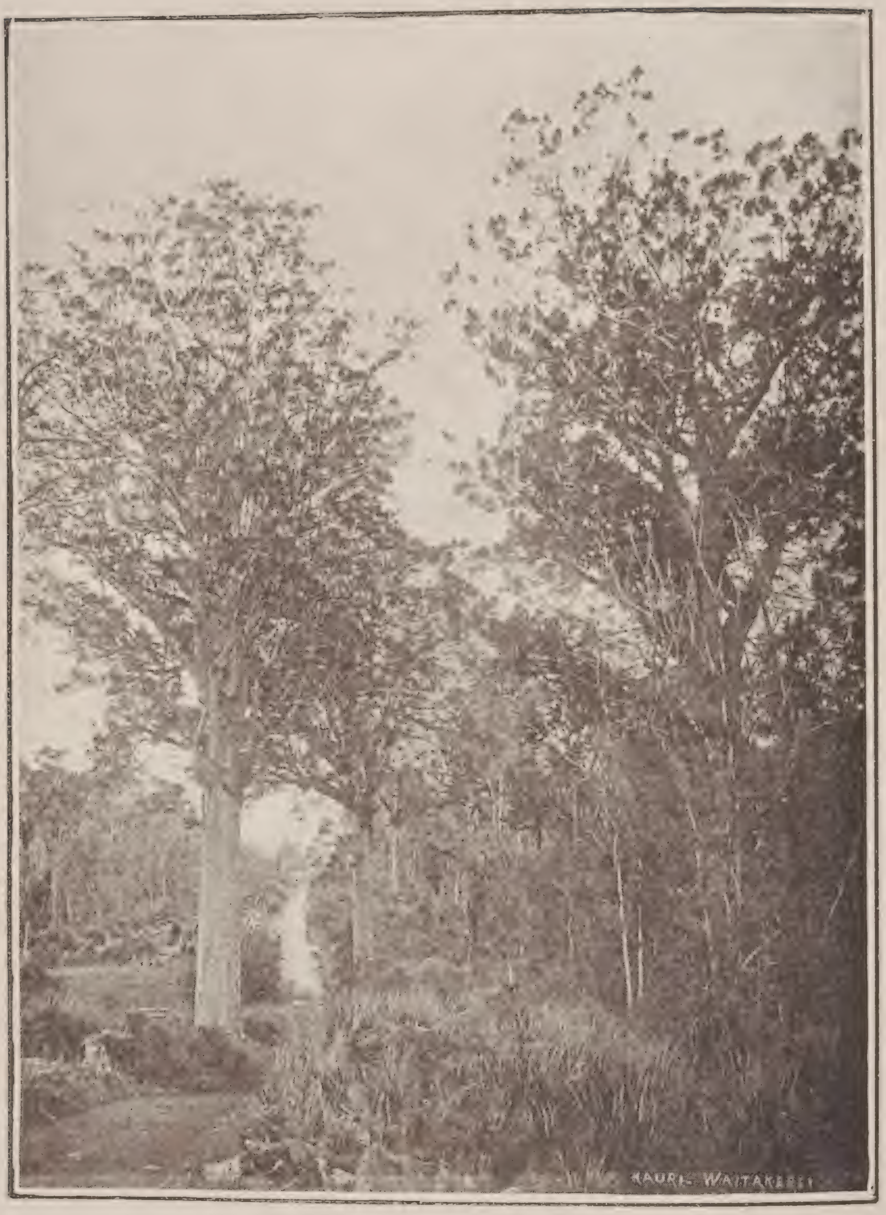
* Courtesy title.

PLATE XIV.



KAURI RESERVES AT THE MID PERIOD.

Small trees left in forest on Waitakerei Hills, Auckland.

Photo, J. Martin.] [*To face p.* 93.

classes in the felling compartments. Ultimately there will be a series of compartments with ages varying from one year old to 100 years old dotted about the forest and numbered from 1 to 100.

Towards the end of the "transition period" there will be a quantity of timber amongst the secondary species that will have to be thinned out, and some of the Kauri timber that in size will be nearly equal to the "Kauri tree of the future," with 2 ft. diameter and 60 ft. bole. The average 35 c. ft. acrim of the "transition period" will be derived mainly from four sources :—

(1.) Virgin forest; some deferred regeneration fellings.
(2.) Kauri reserves at the mid-period. (See Plate XIV.)
(3.) Heavy thinnings towards the end of the "transition period."
(4.) Where suitable, twenty-year crops of butter-box and packing-case timber planted in vacant places.

The last item would be on waste areas falling within the forest-demarcation boundary, perhaps covered with Gorse, Blackberry, or scrub which might eventually, when cleaned with Insignis planting, go into Kauri, Cedar, or other valuable timber forest. Insignis-pine, on account of its high yield of second-rate timber, is best placed in suburban forests. Owing to the neglected condition of forestry in New Zealand there are large areas of such Crown land which, if near a demarcated forest, would naturally be put into it so as to be turned to account.

Revenue other than Timber.

In addition to the timber, there will be some considerable revenue from what is usually termed "minor forest-produce." Here resin-tapping is nearly certain to figure largely (p. 30). It is impossible now to say how much Kauri resin will be tapped—almost certainly from trees before they are felled, and probably also from others. It is possible also that Kauri distillation will be found profitable, with charcoal or firewood as by-products, as all the parts of a Kauri tree, even the leaves, are imbued with resin ("gum"). Firewood, too, and fungus* will also bring in some revenue. Fungus-gathering was helpful to the settlers when butter was only worth a few pence a pound. It is still regularly collected in the northern forests, being sold at 3d. to 6d. per pound for export to China. I have never heard of its being eaten in New Zealand. It is usually found on Karaka and "Whitewood." In Japanese forests, trees are regularly grown to produce fungus, and the matter will no doubt receive attention in the future administration of New Zealand forests. I hope, too, that an industry killed by poor forestry and now extinct in New Zealand—charcoal-burning—may be revived under the protecting care of better forestry ("Australian Forestry," Perth, 1916), together with the teaching of better cookery at the technical schools. Few things would help more to improve a somewhat inferior diet than the substitution of French cookery with charcoal from New Zealand forests in place of cookery with gas or imported American oil.

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* Fungus *(Hirneola polytricha)*.—In 1871 this plant was first collected for exportation to China, where it is used as an article of food, being boiled and mixed with bean-curd and vermicelli; it is also administered as a medicine to purify the blood. Its price in Hong Kong is 10½d. per pound retail. In most parts of New Zealand Chinese merchants pay the collector 3d. per pound, or £28 per ton, for the fungus when dry. Fresh specimens lose four-fifths of their weight when drying. The total quantity exported to the end of 1876 was of the value of £18,294. During the year 1876 alone 2,633 cwt. was exported, valued at £6,224. (Report by Campbell-Walker, Parliamentary Paper, 1877, p. 34.)

Be this as it may, Kauri "gum" and some firewood and fungus are sources of revenue, but they will vary so much from forest to forest that in this balance-sheet for the normal Kauri forest it seemed safer to merge them with Kauri "gum." 190 tons of fungus were exported from New Zealand in 1912. It is easy to imagine how, with cultivated forest as in Japan, this production might be very largely increased.

FOREST EMPLOYMENT AND SETTLEMENT.

A Kauri forest, on account of the value of its timber and "gum," can support an organization as complete as any good forest in Europe. I shall therefore here assume for both labour and forest officials a scale similar to that in force on the Continent of Europe.

Baden, Saxony, Wurtemberg, and Bavaria are four south German States in New Zealand latitudes and climates. Baden, embracing all the western side of the Black Forest mountains, with a heavy rainfall and the forest very well developed, offers, as already pointed out, a particularly good model of forest-management for New Zealand to copy. The permanent employment in these four States, reckoned out at per man per year, is as follows :—

FOREST EMPLOYMENT.

Baden, one man full time per	74 acres	U.S.A., Forest Circular No. 140, p. 29.
Saxony ,,	87 ,,	
Wurtemberg ,,	130 ,,	
Bavaria ,,	130 ,,	Various returns, particularly Quart. Jour. Forestry for April, 1913.
Average ..	105	

Prussia, with forests of a poor character in East Prussia, employs in forest-work at the average rate of one man per 175 acres. One must remember that the State forests of the Kingdom of Prussia represent the larger half of the State forests of Germany. French returns, as mentioned (Appendix, Part II), have not reached me in New Zealand.

In a recent review of my book on Australian forestry (Quart. Journ. Forestry, Oct., 1917), Sir W. Schlich says, "Taking both classes [officials and labourers] of employment together, we may safely say that one full-time man will be required for every 100 acres of properly managed forest."

The Coast Erosion Commission of England in 1908 took 100 acres as a general average. (Lands Dept., 1908, Forestry Rep.) Considering the shorter working-days and other circumstances in New Zealand, I take average employment (labour) *in a normal forest worked intensively* at one man per 75 acres. Thence *for poor forest or inaccessible forest worked extensively* all grades downwards to perhaps that afforded by sheep on purely pastoral farms averaging in New Zealand one man per 3,000 acres. (Part II, "Sheep.")

LAND-SETTLEMENT. (See also p. 113.)

National forestry stands for permanent occupation of the ground. One of the reasons for State forestry on the Continent of Europe is that by State action men are retained permanently in the country and on the soil. Thus one man per 75 acres is the definite occupation, or land-settlement, offered by forestry in New Zealand wherever there is forest that economically can be worked intensively. And this employment and settlement conflicts with no other employment or settlement. On the contrary, it assists them. It has mainly to do with the "unoccupied third" of New Zealand. In Europe, forestry means even more than this, because there are a great number of very small farms where a man can only make a living by working on the farm in summer and in the forest in winter. To a less extent the same practice would be convenient on dairy farms in New Zealand.

In the course of a walking tour through the rich pastures of Taranaki I spoke to many settlers living on 100-acre plots. They had had a hard struggle at first, clearing the bush, were now living comfortably on 100 acres, but could not do it on less good land—viz., on Kauri land.

Forest Officials.

Turning to forest officials, the average Prussian scale is as follows:—

Forest Guards, one man per	1,800 acres.
Forest Rangers, ,, ...	9,800 ,,
Verderers or local forest officers	61,000 ,,

I here take officials at the rate of one Ranger for 2,000 acres. This scale of officials is the general average throughout France, and is that reported quite recently by Mr. H. R. MacMillan, the chief Forest officer of British Columbia, in an account of a French forest in the Jura Mountains (Quart. Journ. Forestry, Dec., 1916). But here one must remember that the French forest officials are also trained soldiers. They form a special corps of "Guides," mobilizable at a word on the outbreak of war.

The forest organization is similar in other countries of Continental Europe. In Germany, where each State has its own Forest Department, the staff varies considerably, perhaps on account of the double function of all the forest staff, military and forestal. An organization so useful in a country where there is so much mountain and bush seems of the first necessity in New Zealand, and especially now for the employment of returned soldiers. I shall allow for it here, and have more to say about it later. (Part II.)

BALANCE-SHEET OF A NORMAL CULTIVATED KAURI FOREST.

In view of what is said above, the balance statement of a normal Kauri forest (but one in which the age-classes will not be fully established for 100 years) will work out for three periods thus:—

	Years.
(1.) Period during which the old timber in the virgin forest is being cut over (approximately) ...	20
(2.) Period during which the forest is yielding a net revenue of about £1 5s. per acre, and growing up into the valuable fully stocked Kauri forest of the future	100
(3.) The normal Kauri forest of the future, with an average net revenue working out to £10 16s. per acre per year, and the other Kauri data (very curiously) nearly all at about 100—viz., the forest matures in 100 years, with not less than 100 Kauri trees to the acre, yielding an acrim (average timber acre-increment) of 100 c. ft. q.g. in 100 trees of 2 ft. diameter and 60 ft. of trunk, each tree cubing about 100 c. ft. q.g.	Perpetuity.

FIRST PERIOD.—THE WORKING OF THE VIRGIN FOREST.

Revenue.—The quantity of timber, and the time taken to work it, will depend on the forest and circumstances of working. For the Waipoua Forest, for instance, the working may take 20 years. The timber there is valued at an average of £18 17s. 10d.[*] per acre, and the Kauri "gum" may be worth 10s. per acre more.[†]

Expenditure[‡].—No general figure can be given for this either, since it depends (1) on the present "stand" of timber, which varies from acre to acre and from forest to forest; (2) on the development that has taken place, and consequently transportation facilities. This should be very good at Waipoua. It was poor when the best of the Puhipuhi was destroyed, very good afterwards. The outstanding feature of the Puhipuhi loss is not only that the forest was worked recklessly, but worked too soon. As a general figure of logging-costs, the secretary of the Kauri Timber Company (Timber Commission, 1909, p. 565) quoted 4s. 5d. per 100 sup. ft. The average in America, U.S.A. (Moon and Brown), is half this.

SECOND OR TRANSITION PERIOD.—THE GROWING-UP OF THE IMPROVED REGROWTH FOREST DURING A TRANSITION PERIOD OF ABOUT 100 YEARS.

An Average Acre of Normal Kauri Forest.

Revenue.—The forest is now growing up largely regularized with a certain number of Kauri standards (young trees) left over for mid-rotation fellings, and such thinnings generally as may be required.

	£	s.	d.
Kauri: Average yearly timber-yield for the period, 15 c. ft. q.g. at 1s. 6d. per cubic foot (12s. 6d. per 100 ft. sup.)	1	2	6
Other timbers: 20 c. ft. q.g. at 8d. per c. ft. q.g. (5s. 6d. per 100 ft. sup.)[§]	0	13	4
Kauri "gum," fungus, &c.: There will be no old trees, but the heavy tapping before felling of the Kauri reserves will yield a fair supply of "gum" at the mid-period and the Kauri thinnings the same at the end—say, altogether[‖]	0	5	0
	£2	0	10

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[*] This is at pre-war prices, and very rough estimates of the timber.

[†] The yield of Kauri "gum" estimated must necessarily vary within wide limits, since so little is known about the systematic tapping of Kauri for "gum." I see no reason why, at least, the amounts estimated here should not be realized. For a forest that is at all accessible the value of firewood will at once make this estimate far too low.

[‡] The cost of special regeneration measures (p. 116) is not set down here. It may amount to £2 or £3 per acre, and is paid for out of fellings; or it may be looked on as balanced by the cost of grassing if the forest were to be destroyed and taken for grazing. In parts of the forest, gum-digging (of course, under strict control) will not only turn over the ground ready for planting, but also pay the cost of the young trees and their insertion.

[§] This figure may seem high, but it includes such timbers as Totara, Rimu, Celery-top (Tanekaha), and Puriri, some of which, where favourably situated, have already touched this figure; and allowance has here to be made for the better growth and accessibility of the cultivated forest. This may be the maximum average price these timbers will reach, though Totara and the best of them may get near Kauri prices.

[‖] The yield of Kauri "gum" estimated must necessarily vary within wide limits, since so little is known about the systematic tapping of Kauri for "gum." I see no reason why, at least, the amounts estimated here should not be realized. For a forest that is at all accessible the value of firewood will at once make this estimate far too low.

The 100 cub. ft. q.g. acrim is now established over the whole forest, but the fully mature timber from this is not fit to cut till the next period.

Expenditure—

	£	s.	d.
Labour at less than half ordinary European rates for this transition period: One man per 200 acres; £150 per man yearly. I take under half the European rate because 60 per cent. of the European rate is for logging, and there will neither be much logging nor much regeneration work during this period	0	15	0
Supervision and police: Local staff—One man per 3,000 acres, at £100 (one-third pay military; French rate, one man per 2,000 acres; police-work here less than in France)	0	0	8
Material and direction taking a round sum of £1,500 yearly for the Waipoua Forest (30,000 acres). This would include regular expenditure, such as for seeds and tools, but not extraordinary charges such as for *aménagement* or "working-plans," Rangers' cottages, or new roads, all of which would be paid for out of the virgin forest timber ...	0	1	0
	£0	16	8
Therefore average net revenue per acre for transition period (£2 0s. 10d., less 16s. 8d.)	£1	4	2

These figures will necessarily vary with the present quality and future prospects of the forest. For a forest that can economically be put into good order now by thinning and interplanting the above figures may be taken as useful general guides. They make no claim to exactitude. The economic value of each forest will be shown by its classification at demarcation and the subsequent "working-plan."

The revenue figure here taken as a rough average at about £1 4s. 2d. will at first depend entirely on the present quality of the forest. This can be easily gauged, but will vary greatly. Later, as the forest approaches a normal condition, there will be less variation, since the figure will depend on thinnings in a better-stocked and more regular forest.

As average figures for the Kauri forests that I have seen and had described to me these figures may be taken as sufficient for general guidance. Their limits of variation may lie between a forest just paying its way, as in the case of a poor or badly placed forest, to figures considerably higher than here estimated, as in the case of a well-placed Kauri forest containing a good stock of young timber, like Trounson's Kauri Park, for instance.

THIRD PERIOD.—NORMAL FIGURES FOR THE KAURI FOREST IN FULL WORKING-ORDER.

The forest by this time, 80 to 120 years hence, is fully stocked, or somewhere near it. This is the first essential, for fertile New Zealand is not the country for unproductive land! The forest is also well on its way to that gradation of ages which is essential to regular production coupled with economical milling. Foresters will gradually complete the age-classes as they regulate the fellings. For this third period it becomes possible to frame with more exactitude the figures of revenue and expenditure, using figures from forests in a similar condition in other countries. The preceding figures, depending more or less on the present quality of the forest, are variable. The following figures, with the forest better stocked and approaching regularization, are definite and variable only within certain close limits :—

Revenue—

	£	s.	d.
Timber yielded by the 100 c. ft. q.g. Kauri acrim referred to above (p. 92), at 2s. per c. ft. (p. 105) (16s. 8d. per 100 ft. sup.)	10	0	0
40 c. ft. q.g.*, more or less, of other timbers, at 8d. per c. ft. (5s. 6d. per 100 ft. sup.)†	1	6	8
Kauri "gum" from a fully stocked Kauri forest, with light tapping from all the trees, and heavy tapping from those being felled: as a rough general estimate, say £1 11s. per acre per year, including fungus, firewood, and all minor forest produce‡ ...	1	11	0
	§£12	17	8

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* The 40 cubic feet q.g. of other timbers is uncertain. It depends on just how much space is required for the best growth of the 100 cubic feet q.g. of Kauri.

† This figure may seem high, but it includes such timber as Totara, Rimu, Celery-top (Tanekaha), and Puriri, some of which, where favourably situated, have already touched this figure; and allowance has here to be made for the better growth and accessibility of the cultivated forest. This may be the maximum average price these timbers will reach, though Totara and the best of them may get near Kauri prices.

‡ The yield of Kauri "gum" estimated must necessarily vary within wide limits, since so little is known about the systematic tapping of Kauri for "gum." I see no reason why, at least, the amounts estimated here should not be realized. For forest that is at all accessible the value of firewood will at once make this estimate of revenue far too low.

§ It should be noted that the gross revenue of £12 17s. 8d. per acre here estimated is a middle-course figure. The extremes would be,—

Minimum value of net revenue per acre—

	£	s.	d.
Kauri 105 to 120 years hence with no further rise beyond 8s. 4d. per 100 ft. sup. and a kauri acrim of only 100 c. ft. q.g. ..	5	0	0
"Gum," firewood, and fungus, as above	1	11	0
Other timbers, as above	1	6	8
Gross revenue	7	17	8
Less expenditure	2	1	8
Net revenue	£5	16	0

Maximum value of net revenue per acre—

	£	s.	d
Kauri 105 to 120 years hence, at double present prices—say, 2s. per c. ft.—and an acrim of 200 c. ft. q.g.	20	0	0
Other timbers completely dominated by the Kauri and with practically no timber acrim	0	0	0
Kauri "gum" and firewood, say	3	0	0
Gross revenue	23	0	0
Less expenditure	3	0	0
Net revenue	£20	0	0

Expenditure—

	£	s.	d.
Labour at full European rates for a fully stocked forest: Permanent yearly average at the rate of one man per 75 acres—man at £150 yearly, with house, ground, &c. Labour includes all forest work up to putting the logs by the roadside, road-making, timber-felling, natural-regeneration aid work, and interplanting where necessary... ...	2	0	0
Supervision: One man per 2,000 acres, materials, and direction as above, per acre per year	0	1	8
	£2	1	8

Therefore average net revenue per acre for the third or final period is £12 17s. 8d., less £2 1s. 8d. = **£10 16s.**

At 4 per cent. £10 16s. capitalizes to **£270.** This is an important figure in considering land-values, since on a 4-per-cent. basis, or twenty-five years purchase, land under normal Kauri forest will have a capital value of £270. Just as the stocking and age-classes of any existing Kauri forest approaches the normal Kauri forest will its present value (capitalized at 4 per cent.) approach £270 per acre. *Thus it is only land in the very best districts of New Zealand that has a higher value than well-stocked Kauri-forest land.* This brings one round to European conditions, where patches of forest land and agricultural land stand side by side, and it wants little change in relative prices to say which is the most profitable.

I have taken 4 per cent. for capitalizing here because that is the usual return expected from Government securities in New Zealand, but European Governments are satisfied with 2½ or 3 per cent. from forest property, for various reasons, amongst which are the indirect national benefits of forestry. Capitalizing the normal Kauri forest at 3 per cent. a net yield of £10 16s. per acre per year represents a capital value of £359 12s. 9d.

The percentage yield of a forest is a technical subject which cannot be discussed here. Quite commonly the least productive forests in a national sense, such as mere fuel copses, have the highest percentage yield. (This is one of the early surprises of forest economics.) *It will be well here to remember that while at 4 per cent. the capitalized value of the normal Kauri forest is £270, at 3 per cent. it is (in round numbers) £360.*

Comparative Value of Present and Future Timber Crops in a Normal Kauri Forest.

Let us assume that the present value of Kauri royalty is 8s. 4d. per 100 sup. ft. (= 1s. per c. ft.), and the future value 2s. per cubic foot. Then 10,000 c. ft. q.g., the normal stand, is worth, if cut now ... £500

An acre of virgin forest heavily stocked with timber would, of course, represent a much higher value, but that is not economical production, and need not be considered here. Indeed, a single sound giant Kauri tree might represent a timber value of over £500.

With Kauri risen to 2s. the cube, and capitalizing at 4 per cent., the capital value of all future Kauri and accompanying forest crops is £270
at 3 per cent. is £360

Here it is noticeable that if timber-prices continue to rise as they have been doing all these three values will rise together; but if systematic Kauri-resin tapping develops to a great industry, as in Gascony, it is the items of £270 and £360 that will be chiefly benefited, bringing the value of present and future timber crops more on an equality.

Discounted Present-day Value of Future Kauri Crops starting after a Transition Period of 100 Years.

It remains to consider the case of a Kauri forest at its worst, when there is no present timber crop and no future timber crop till after the lapse of 100 years. Apart from all timber now on the ground, and apart from all timber crops maturing during the next 100 years, the present value of the normal Kauri forest discounted at 4 per cent. is $\frac{£270}{50\cdot5}$ = £5 7s. (£50·5 being the amount of £1 at 4 per cent. compound interest for 100 years). So that *£5 7s., less the cost of "interplanting" Kauri standards, is the minimum public value of Kauri land with no Kauri at all on it at present.* Turning to p. 131 one sees that the cost for full "interplanting" Kauri standards is about £2 per acre. So that, everything considered, Kauri land cannot be worth less than £3 7s. per acre to the Dominion as a public asset, supposing that at the present day there is not a Kauri tree, sapling, or seedling left on it. It might now be only Manuka scrub!

On the other hand, the Puhipuhi Forest with its abundance of young Kauri (p. 67) represented the maximum value of a Kauri forest, one that could be worked straight-away as a normal forest. £270 per acre was its value after the mature timber had been worked off it. The Balance-sheet above represents medium conditions, such as prevail in ordinarily good Kauri forest to-day, where there is a transition period of 100 years before the forest can be got into the condition of a fully stocked normal forest, but enough young timber maturing during the 100 years to yield a profit equal to dairying on this class of soil.

EXPENDITURE AND EMPLOYMENT FIGURES DISCUSSED.

It may be said that expenditure at the rate of 16s. 8d. per acre for the transition period, or £2 1s. 8d. afterwards, spent yearly on a Kauri forest would amount to an enormous figure at compound interest in 100 years. So would the cost of running a railway per mile. But in each case we look on the money-earning concern as a whole. Money goes into the machine at one part and comes out at another!

The final permanent expenditure of £2 1s. 8d. per acre may be compared with some European figures for forest worked intensively, bearing in mind that European labour is about half the cost of New Zealand labour; but against this Kauri is about double the price and grows about twice as fast as European coniferous timbers, so that somewhere about four times European figures would be justifiable in New Zealand.

EUROPEAN EXPENDITURES PER ACRE PER YEAR.

	£	s.	d.
Sihlwald (p. 79), a model Swiss forest, practically suburban	1	16	7
State of Baden, average for all Government forests ...	0	14	3
State of Saxony ,, ...	0	12	0
State of Würtemberg ,, ...	0	8	2
Prussia, with much forest on poor sand, average for all Government forests	0	6	3

In Europe the forest officers generally express themselves satisfied when the gross revenue is about double the expenditure. This is the case taking the average of French Government forests. At this rate (half the gross revenue) the expenditure on a fully established normal Kauri forest might go up to £6 8s. 10d. per acre per year, or three times my estimate. Be this as it may, there is always the comforting reflection that this would mean permanent settlement at the rate of one man per 25 acres. Thus, whether I have overestimated or underestimated the expense of working a Kauri forest scientifically, the country stands to gain either way—viz., *in either lowered taxation or increased population.*

Germany on all its forests, Government, private, and forests held on three other tenures, spends £8,000,000 yearly. South Africa spends £200,000 yearly on its Government forests and plantations, or four times the present forest revenue. New Zealand in 1916–17 spent £27,150 on plantations of promising but necessarily risky exotics, and £653 on management expenses of so-called State forests. It will be recalled that State forests in New Zealand are areas reserved for destruction by millers, not State forests in the usual meaning of the term.

HIGH NET REVENUE.

£10 16s. per acre per year is a high net revenue from even the most productive forest. It will be criticized. The various figures on which it is founded have already been discussed. The Kauri "gum" and "other timbers" are uncertain, but do not bulk for much in the estimate; the former is probably underestimated. Of the £12 17s. 8d. only £1 11s. is the estimated yield from Kauri "gum," firewood, and all minor forest produce. No one yet knows what systematic resin-tapping will produce (p. 30). If resin-tapping should be abandoned altogether for Kauri, the correction to these figures is but slight and is easily made. It is much more likely that Kauri resin-tapping will be conducted successfully, and that there will be a substantial addition to these figures in consequence.

The timber-yield item in the above estimate figures at only 140 c. ft. q.g. per acre per year, of which 100 is from the Kauri and 40 from other timbers. This is a comparatively low figure for such a climate as New Zealand, and is certain to rise. European forest-yields show gradual steady rises everywhere. The forests of Prussia, for which there are the oldest and most reliable statistics, have increased their timber-yield nine times, and their money-yield more than ten times, during sixty or seventy years—a man's lifetime (p. 72). Details are given in the Statistical Appendix (Part II). Against 140 c. ft. q.g. assumed here, the coniferous forests of mid-Europe show yield-figures going over 200 c. ft.; and in the latitudes of the Kauri forests much higher figures are on record.

As regards the net forest income arrived at, it must be remembered that the economical circumstances of New Zealand are exceptional, there being no softwood coniferous forest in neighbouring countries to compete with New Zealand. Half this figure of £10 16s. has already been realized from the best coniferous forest in central Europe over small areas (more than half from some suburban forests), when there has been nothing approaching a timber scarcity, but where, on the contrary, American stumpage-gamblers, with the best parts of the forests of the country in their grasp, and seeking only "to cash their stumpage," have been flooding Europe with low-priced timber; some of this timber, too, worked by cheap coloured labour—negroes in the United States; and Hindus, Chinese, and Japanese in Canada.

Tariff Protection for Home-grown Timber.

As I shall mention elsewhere, if there is a strong case anywhere for a high import tariff it is to protect the impoverished forests of New Zealand, and their industries, against this unfair temporary competition —timber "dumping." By the time that the Kauri and other forests mature as cultivated forests, with perhaps ten times their present average productiveness, foreign timber will have ceased to trouble home industries. Most of the private forests in North America will have gone the way of private forests generally, and the national forests will be insufficient to supply national needs in America, leaving nothing for export. As much as four-fifths of the present merchantable timber in the United States is private. Siberian forests are earmarked for the supply of Europe and a civilized China.

European Forest Revenues.

The following average yearly net revenues from cultivated forests in Europe may be compared with the £10 16s. estimated for the normal Kauri forest:—

	£	s.	d.
Baden, net revenue, average for all State forests (mixed forest)	1	2	3
Würtemberg, net revenue, average for all State forests (mixed forests)	1	10	4
France: *La forêt de Levier*, Jura Mountains (Spruce and Silver-fir)	3	3	0
France, Besancon Forest (Spruce and Silver-fir) ...	3	9	0
Baden: Black Forest, best part (Spruce and Silver-fir)	3	10	7
Germany, over small areas	5	0	0
Germany, at suburban forest, near Frankfort (mixed forest)	5	6	9

These net revenues must be less than that from Kauri forest, for three reasons: (1) Most of the timber from these forests is less than half as valuable as Kauri; (2) it is produced in a colder climate of less tree-growth; (3) it is exposed to the dumping of the present-day American timber speculator.

I have selected the above figures as representative of normal conditions in cultivated European forests known to me. Figures over larger areas might not represent normal conditions. Thus the general yield-figure for the State forests of Prussia when war broke out was 70 c. ft. per acre per year, but this has been unduly lowered by a large area (125,000 acres) of poor forest overburdened with old rights of usage (chiefly litter removal), together with ruined forest and waste land, that have been bought in lately and added to the area of the national forests. (For other forest revenues see Statistical Appendix, Part II.)

My Estimates easily tested.

The figures discussed above are sufficiently close to indicate the general trend of forest policy for the Kauri and better-class forests of New Zealand. Professional foresters, with the advantage of living permanently in the Dominion, will be able to frame closer estimates. An opportunity was lost when the Puhipuhi Forest was destroyed before a forester had been able to measure its growth-figure (acrim) and timber stand. But doubtless there are still small areas of fully-stocked Kauri forest, similar to that I measured at Waipoua, which will be better stocked and indicate more clearly the exact value of a fully-stocked normal area of Kauri; and Kauri is now so valuable, and the waste in working so greatly reduced, that the yield of sawn timber from selected well-stocked areas will give valuable data. The collection of such data from all classes of forest will be one of the subjects to first engage attention as soon as there is forestry and a Forest Department in New Zealand. (For fuller details regarding European forests statistics, the Statistical Appendix (Part II) as above should be consulted.)

NEW ZEALAND TIMBER-PRICES FROM DOUBLE TO FOUR TIMES EUROPEAN.

When war broke out statistics showed that the all-round price of wood from German forests was 3¾d. per cubic foot. (*Forestry Quarterly*, Washington, December, 1913.) In Baden, which I take as a model State for New Zealand to copy, the average price was 3½d. (Statistical Appendix, Part II.) A few years previously Professor Zon, in "Forest Resources of the World," had assumed 3½d. as an all-round value. European prices are slowly rising. These are values in the log, delivered to the nearest roadside.

3¾d. per cubic foot equals 3d. per cubic foot quarter-girth measurement. At 1 c. ft. q.g. = 9 sup. ft., we have per 100 sup. ft. a price of 33d., or 2s. 9d. per 100 sup. ft. If to this one adds 1s. 6d. per 100 sup. ft. as the price of sawing in Europe, the average price of sawn European timber in the forest comes to **4s. 3d.** per 100 sup. ft.

New Zealand Prices at Forest Mills.—Average prices for sawn timber per 100 sup. ft. at one of the sawmills about midway between Wellington and Auckland shortly after the outbreak of war were—

	£	s.	d.
Totara (11s. to 22s. for selected heart)—ordinary building … … . . … … …	0	12	0
Rimu (9s. to 20s.)—ordinary building … …	0	9	0
White-pine—ordinary … … … …	0	9	0
Black-pine (9s. 6d. to 17s.)—ordinary building (average)	0	9	6
Kauri—general average for all classes at the mills …	1	0	0

The practical evidence of the difference in the value between timber ex European forest mills and timber ex New Zealand forest mills is seen in the fact that timber can be floated down the Rhine, be shipped with "Baltic" to Australasia, and there compete with home timber.

Actually the difference is greater still, with the bad distribution of forest in New Zealand and the good distribution in Europe (see map, p. 188). Belgium has its best State forest, its second largest, abutting on the streets of its capital. New Zealand has banished its forests to such a distance that 2s. or 3s. per 100 sup. ft. has to be added to the price of all sawn timber; and firewood is nearly quite cut off. The firewood coming over the railways to the large towns in New Zealand is less than a quarter of that used in central Europe: thus, New Zealand, *per capita*, 4; France and Germany, *per capita*, 18 c. ft.

Accurate figures for the market-value royalty of New Zealand timbers are wanting, because practically all timber except Kauri, and sometimes Totara, instead of being sold at market rates, is given away at arbitrary rates, which are not in favour either of the country's finances or of the careful and skilful miller. As in Australia, it is one of the evils of non-technical forest management, and will be referred to later.

For Kauri, however, figures are available, and we may compare this with the timber in the best revenue-producing forests in Europe—the Spruce of Saxony. Saxony timber (market royalty), as will be seen in detail under "Policy," averages 4s. 2d. per 100 sup. ft. We may safely take double this as the after-war open-market value of Kauri timber in an accessible well-roaded forest, and this is the class of forest that has to be taken for comparison (see my "Journal of a Forest Tour": Miller, Cape Town).

KAURI ROYALTY—PAST AND FUTURE.

The rise in the value of Kauri royalty or stumpage plays such an important part in these estimates that it is necessary to consider it in some detail. Originally, as mentioned in the history of the Puhipuhi Forest (p. 64), the Kauri royalty was arbitrary, and bore no relation to the true value which would be represented by the market value of sawn Kauri timber, less costs of logging, sawing, and delivery.

Royalties in India are framed on the difference between working-costs and market prices, with the double check afforded by forest working being both Government and contract. This is the only sound principle to follow, and should be adopted in New Zealand in place of the nominal rates now in force, especially south of Auckland, as the result of political pressure and improvident destructive working in the past.

The present royalty on Teak in Burmah is 6s. 8d. per 100 board feet —9·6d. (say, 9½d.) per cubic foot. Teak in India is what Kauri is in New Zealand. Labour in India is about one-twentieth the cost of labour in New Zealand, and it might be argued that with labour so low they could afford to pay higher royalties. But the fact is that with the cheap Indian labour all other commodities (except imported articles) are also very low-priced: so that as prices go in the country the 9½d. royalty on Teak is high compared to royalty on Kauri in New Zealand.

KAURI—OLD ROYALTY.

Forty years ago, when Dargaville was built, Kauri timber was mostly used, and the sawn timber cost 6s. per 100 sup. ft.—a price that is now less than the open-market royalty. There was not much left for the forest out of that! Those were days when Kauri forest, one of the most valuable forests in the world, was destroyed for a few pence, ready money, per tree.

In 1896 the settlers' ordinary payment for Kauri, either on their own or other land, was 4d. per 100 sup. ft. When Ranger Maxwell went to value the Kaihu Railway Company's Kauri his figures were worked out on a basis of 4d. per 100 sup. ft. (under ½d. per c. ft.).

It is true that the Government royalty rate was 1s. or 1s. 3d. per 100 sup. ft. Thus in Kirk's time, twenty-eight years ago, it was 1s. 3d. per 100 sup. ft. = 1·8d. (say, 1¾d.) per c. ft. But payment in those days was on mill output: thus the actual royalty on logs in the forest might not be half this. In practice even these rates were often lower, because only a little time was required for a good Kauri forest to become a burnt one, with special low rates for the burnt timber!

KAURI VALUE DOUBLED IN FIFTEEN YEARS.

During the last twenty years there has been a steady rise in the value of Kauri royalty or stumpage; and in recent years, when the end of the old stock of timber came clearly in sight, a rapid rise. Kauri prices now rule exactly double what they were fifteen years ago for practically every class of Kauri timber. Looking through a file of Auckland timber-merchants' price-lists, I see that in fifteen years Kauri has exactly doubled in value: thus, in July, 1901, Kauri, first class, 14s.; July, 1916, Kauri, first class, 28s.; again, Kauri, medium, July, 1901, 11s.: the same Kauri now 22s. 6d.

FUTURE KAURI ROYALTY.

We may take it that Kauri royalty will run 8s. 4d. per 100 sup. ft. (1s. per c. ft.) within the next few years. What it will eventually rise to is an important point in forestry finance. Within the last fifteen years the average price of a tree in South Africa (Stinkwood), like Kauri in timber-value, has risen in royalty value from 1s. to 2s. per c. ft.: similarly Australian Red Cedar. This is the true royalty value proved from sales by auction.

There is every indication that the market price of Kauri stumpage will also advance to a maximum of 2s. per c. ft. (16s. 8d. per 100 sup. ft.) in the course of the next eighty to a hundred years, the time when Kauri will again be abundant in New Zealand, if the purposeless destruction of the Kauri forests be stopped now. The Sydney *Bulletin* of the 17th January, 1918, contains the yearly report of the Kauri Timber Company for 1917, showing a profit of £59,108 and a 6½-per-cent. dividend. The report adds: "At one time the company reckoned its Kauri areas were depreciating pretty rapidly, and wrote down their book value year by year as the getters put the axe in. But a revaluation disclosed the fact that its remaining forest giants were enhanced beyond the value of the original properties."

TIMBER CLASSES.

The world's timbers are classified into—

First-class timbers: Durable softwoods, such as Cedars (Pencil-cedar, New Zealand Cedar, American, Australian, Indian, African), Teak (which works as a softwood though weighing 40 lb. to the cubic foot), and Kauri. There is a famine approaching in this class of timber. Here also belong certain specially useful timbers, such as Blackwood, Ash, and Hickory.

Second-class timbers: Perishable softwoods—ordinary pine and deals. The bulk of the world's timber used. There will be comparative scarcity but never famine in this class.

Third-class timbers: Durable hardwoods useful for special purposes, such as railway-sleepers, bridge-work, and house-beams. Really durable hardwoods are probably as scarce as durable softwoods.

Fourth-class timbers: Perishable hardwoods. Tropical forests are full of this class. It has no value at present except for trifling supplies of fancy woods. It may be the world's fuel-supply when the coal-supplies are worked out. (*Vide* "A One-sided Fuel-supply," Part II.)

The world's first-class timbers can be counted on one's fingers. Each country that has them in its forests will, with certain exceptions, want every scrap of them in the future. Tasmania might export Blackwood, but it would require a revolution in present Government methods to put the forests in order to do so. India has preserved its supplies of Teak, but not increased them, as the Dutch have done in Java. I can see no serious competition to Kauri in the world's markets in the future. It must rise steadily in value for the present, and rapidly when the famine in this class begins.

MNEMONIC—PRESENT-DAY VALUE OF THE NORMAL KAURI FOREST.

With an acrim 100 and 2 bob the cube,
Less than double the price of Kauri to-day,
Normal forest yields 10 pounds and 16 net yearly.

If there's no young timber and a wait of a century,
Land-value becomes then 2 hundred and seventy,
Or at 4 per cent. now 5 pounds 7 nearly.

KAUR FOREST LEFT.

The destruction of the Kauri forest in the past, according to Anglo-Saxon traditions without examining its value, is evidently a national calamity, comparable in its effects to the present war. That is a statement that will not be readily accepted by those who have grown up with the forest policy of the past, but facts are stubborn. A large-scale map of Europe (p. 188) shows how the development of modern industrial Europe has taken place on lines exactly the opposite of development in New Zealand as far as forestry is concerned, and to the traveller in Europe that development, up to the outbreak of war, was marvellous. That was the verdict of the ninety Englishmen who went through the German forests on the official tour in September, 1913, with Sir W. Schlich, the Professor of Forestry at the Oxford University. England, comparatively, was stationary. The large-scale war maps show clearly how suburban, communal, and other forests in mid-Europe are located near centres of population to supply them with timber and firewood, which are economic necessities of civilized life as much as food and water supply. Under "Forest Policy" I shall give some particulars of town and suburban forests in Europe. It has been shown above how Kauri must be regarded as not only the biggest timber-yielding tree in the world, but also one of the most valuable of timber-trees.

In quite early days it was evident that Auckland was becoming an important centre of population. Yet its future wants were not provided for. The scrub, the poor forest, the good forest on land too rich to keep under forest, the priceless forest of Kauri on poor soil, all went together as the result of indiscriminate destruction without demarcation! By 1903 (incredible as it may seem) the Land Commissioner, Auckland, reported "there are scarcely any forest reservations within forty to sixty miles north or south of Auckland, as almost every inch of that ground was disposed of thirty years ago."

There is no evidence that anything then was known of what was going on in the Continent of Europe, where the broken and impoverished wild forests had been turned into cultivated forests of ever-increasing value, the Church lands and princely estates that had come down from feudal times forming the nuclei for the building-up of the modern national forests. Instead of this, provincial ideas were in fashion at Auckland —a penny of ready money to-day and the future to take care of itself!

As the forest retreated, with the policy of indiscriminate destruction without forest demarcation, first firewood became valueless, then fencing-poles, and then timber. Meantime in Auckland the price of living was rising, Kauri (the sole timber cut in those days) was ever increasing in value, and to-day, as has been seen, average prices are more than double those of fifteen years ago, while firewood is at famine prices at every large town in the Dominion. The timber industry, which was worth about a million a year to the Auckland District, was obviously doomed. It was the best rural industry, employing the greatest number of hands, but for some reason it did not exercise its influence, possibly because it was thought that a "backwoods" policy of forest destruction was inevitable.

As the forest was pushed farther and farther away from the City of Auckland, where it was most wanted, its working and utilization became more costly. The timber was first given away at low prices, then at nominal prices, and then ceased to have any value. Finally came a time when, with the communications available, the forest was too inaccessible to work at any price. Thus it has come to pass that there is still a remnant left, and a remnant very precious to the country, at this time when it is saddled with the war expenditure; and there is the further advantage that the development of this forest fits post-war conditions of employment. The following figures show that the quantity of Kauri forest left is no negligible quantity, but the most prompt action is necessary to save it for the country. It must be remembered that, apart from certain special areas of extraordinary value (in wild forest) the cultivated forest produces ordinarily, per acre per year, from five to ten or fifteen times as much timber as the wild forest, so that the demarcation and liberal redemption of the forest that is left should result in the complete restoration of the Kauri industry to what it was when it did so much for Auckland City and district.

Quantity of Kauri Timber left.

In "Forestry in New Zealand," p. 12, 1909 (Lands Department), the mature Kauri timber left to the Dominion was set down thus:—

In private forest	276	million sup. ft.
In Government forest	210	,,
Total	486	,,

The last Forestry Report of the Lands Department (March, 1917) stated that Kauri is being now cut at the rate of 52 million sup. ft. yearly: at which rate the Kauri forests will be finished in seven years.

In Auckland I had an estimate this year of the total quantity left in Government forest as approaching 300 million sup. ft. The Waitakerei purchase may partly account for this more favourable position.

From further inquiries that I have now made, and from an estimate that Mr. Kavanagh has been good enough to check, it seems that the total quantity of Government Kauri timber now left is something like the following:—

Waipoua Forest	80	million sup. ft.
Warawara	60	,,
Puketi	100	,,
Waitakerei, &c.	30	,,
Total	270	,,

These figures will be taken for what they are worth. Their value is chiefly as a rough indication of the quantity of demarcatable Kauri forest left. A recent return (October, 1918) makes the total about 200 million sup. ft.

RETURNED SOLDIERS.

In the "Balance-sheet of a Normal Kauri Forest" above it will be noted that one-third of the pay of the local forest staff is considered debitable to the Military Department (p. 97). It is assumed that New Zealand will copy the forest organizations which have proved so successful on the Continent of Europe, where the forest staff fits into the military organization of the country as a *corps d'elite* of guides and pioneers. The opportunity which is now offered to New Zealand for the formation of such a forest service, with a number of more or less invalided soldiers on its hands, is unique. There will be many returned soldiers without the taste or ability for settling on the land as farmers, but who could be settled on the land in the Forest Department, either as officials or permanent labourers, with just as much work as they were able to accomplish. Indeed, it seems doubtful at this juncture which has the strongest claims on the country—the forest or the returned soldiers. Happily the presence of one offers a unique chance of doing justice to the other. This subject is discussed in "Forestry Policy," and at pp. 45 to 48 of my "Australian Forestry" (Perth, 1916).

There is a wide field for the employment of soldiers as daily-paid men in the great work of roadmaking and forest development which must be put in hand as soon as New Zealand determines to turn its forests to account as in Europe. There would be work of all sorts here—the heavy work of roadmaking, timber-felling, ring-barking, and grassing; the lighter work of teamsters, sawyers, planting, and hand or disc mulching, and some quite light work in the nurseries. In what follows it will be seen that there is much light work which partially disabled soldiers could undertake—work which is done by women and children on the Continent of Europe, greatly to the benefit of their health and physique. English habits and prejudices will prevent them taking to this work at once in New Zealand, so that in the meantime there is here a chance for disabled soldiers. Light work out-of-doors and in the country offers to disabled soldiers their best chance of renewed health and strength.

TIMBER PLANTATIONS AND SETTLEMENT.

Perhaps the saddest of the mistakes made in the Government plantation is the social one—absence of land-settlement. It will be discussed later under "Policy." The branch of the New Zealand "mixed" forest on the extreme southern coast of Africa, Knysna, supports a white population at the rate of one family per 100 acres. The forest is in poor order, the support insufficient, but the population is wedded to the soil, and efforts to remove some of them have failed. The Germans spend some £7,000,000 yearly in wages to men working in the cultivated forests. They work half of the year in the forests and half on their farms. But such forest colonization has been missed entirely in New Zealand. After twenty years' working and the sinking of two millions the Government timber plantations are still dependent almost entirely on prison and casual labour. This state of things is good neither for the labour, for the cause of settlement, nor for the forest work, which is largely skilled work and benefits from a trained staff.

I have had a long experience (twenty-three years) with timber plantations and prison labour. I have found it satisfactory up to a certain point, but, of course, it means losing the land-settlement.

In view of returning soldiers and urgency, I have suggested (4th January, 1919) that some 167 cottages and farm lots be provided now, and eventually about 1,000, supposing that the present timber plantations are terminated with an area of about 35,000 acres. The British official scale for timber plantations is one man full time per 70 acres of plantation, or 500 men for the New Zealand 35,000 acres. But on the European forest plan, working half-time on the farm and half in the forest, 1,000 men (or families) could thus be settled on the land.

Such a scheme may be more attractive to some soldier settlers than the high-priced land of subdivided estates or the isolation and heavy work of the backblocks. The one-man-per-70-acre scale includes all work up to the felled log brought to the roadside. It excludes the sawing employment, which in most cases would come in too. Two-thirds of the Government plantations are in the Rotorua group; and near them is much pumice land open for settlement. At the Whakarewarewa Forest station is a particularly fine pasture, but it has taken some time to form on such land. Similar pasture might be laid down near each forest-labourer's house, the interest on the cost going on to the house-rent.

VALUE OF THE NEW ZEALAND FOREST.

Kauri forests of great value and Kauri forests which without costing the State a penny could have been worked up to a normal Kauri forest have been destroyed for pasture, under the impression that the pastoral value was greater than the forestry value. The private owner must destroy and grass, unless he is a wealthy man and can afford to wait many years for a return.

The State has to look at the matter from other points of view—greatest value over periods of years, reckoning money interest; money profit to the State so as to reduce taxes; cheap timber and firewood for the country, helping permanently to keep down the cost of living; permanent settlement on the land in the smallest possible occupation areas; floods and soil-erosion; together with important secondary considerations such as climate, beauty, nature reserves, and recreation areas. To carry out these objects the first consideration is finance. The forestry figures for a normal forest are worked out above. I have taken Kauri. It is not difficult to take proportionate values for Totara forests and for the ordinary "mixed" forest. Beech forest will require to be considered separately.

Kauri, Totara, and other Forests.

It will, of course, be understood, from the scale of revenue and expenditure set forth in the "Balance-sheet" above, that there are infinite gradations of forest from the fully stocked Kauri forest to the forest that will yield little for many years, and so can now only have a little spent on it. A forest of fair quality will at first yield profits, and afford occupation and settlement on the soil, at about the same rate as dairying on poor soil, such as the ordinary Kauri-forest soil. After sixty years (White-pine), or eighty or a hundred years (Kauri, Rimu, or Totara), the cultivated forest will have become established. The net yield, at prices which may then be expected to prevail, will vary from about £10 16s. per acre per year (for a normal Kauri forest as detailed above) to three-quarters to one-half, or to less than this figure, depending on the value of the timber "stand" as compared to a normal Kauri forest. Totara may come very near Kauri. As a durable softwood, Totara amongst timbers comes into the same high class as Kauri. Like Kauri, there is certain to be a great demand for it in the world's markets of the future. If, as is highly probable in the cultivated forests, foresters succeed in getting rid of its unsoundness, the "kaikok" rot, Totara may rise to a value nearly equal to Kauri. The loss from "kaikok" rot is estimated by Kirk to amount in the present old trees to between 40 and 50 per cent.

NEW ZEALAND'S TWO BEST TIMBERS BOTH PEERLESS.

Many of the best timbers in New Zealand are Podocarps; all the large timbers of South Africa are Podocarps ("Podo" is the miller's term in British East Africa); there are other fine Podocarpus timbers in Japan, Chile, and the tropics; but within my knowledge *Podocarpus totara* is the best of all the Podocarps, exactly as New Zealand Kauri is the best of all the Kauris. It is a singularly happy circumstance that the two chief timbers of New Zealand each belong to a class of valuable timbers, and each is king of its class!

Kauri, Totara, and Rimu easily distance European timbers. Rimu and Totara taken together are better than Oak, since Totara is more durable (judging by average sleeper-life) out-of-doors, and Rimu is more beautiful. The selected Rimu panelling one sees in good New Zealand houses easily surpasses Oak panelling and wainscotting in European houses. There is little doubt that Totara and Rimu taken together equal or outdo Oak, and the two of them are more abundant in New Zealand forests than is Oak in European forests. Kauri might be compared to Oak, though in every respect but strength it is superior. To find an equal to Kauri one must search the world through. As a tree, Kauri grows some 50 to 75 per cent. faster than Oak; it is less unsound, and attains a much greater size and longevity. Its timber is more easily worked than Oak, and somewhat more durable.

European Scotch-pine is easily distanced by the less abundant but first-class timbers of New Zealand—Puriri, Celery-top or Tanekaha, the Cedars, the Silver-pines. The first two, and perhaps the Silver-pines, will have an extended utility in the cultivated forest.

White-pine, now engaging so much attention in New Zealand, is discussed in a separate chapter of "Forest Policy." It ranks with the white perishable softwoods of Europe, Spruce and Silver-fir; but as a tree White-pine grows larger and probably faster.

TOTARA A CEDAR.

Kirk in his Forest Flora discusses the relative merits of Kauri and Totara. It will be sufficient here to note that Totara is imbued with an essential oil which gives it its superiority over ordinary softwoods, and puts it into the same class as the true Cedars, *Cedrela* and *Juniperus*: indeed, the colour, easy working, essential oil, and brittleness make Totara practically a Cedar in timber-classification. The largest of the world's true Cedars, the pencil-cedar of the future, is *Juniperus procera* of the East African highlands. This is affected by a heart-rot similar to "kaikok." It is unfortunate that for business purposes and the world's markets Totara has not been called a Cedar. It only lacks the Cedar smell; but so also does the Australian Cedar, *Cedrela australis*. It is curious that the chief virtue of Totara, its antiseptic essential oil, has come to be reckoned a drawback in New Zealand. The woodwork of houses in New Zealand, in spite of the offensiveness of paint to the artistic sense, is still mostly painted, instead of being wood-oiled; and the natural oil of Totara makes it difficult to paint Totara wood without some preparation.

The sterling qualities of Totara are seen in the houses built of it forty or fifty years ago, and with the timbers still quite sound. As a fancy wood, waved and mottled Totara is of a wonderful beauty and depth of grain, and this fancy wood seems more easily procurable than Kauri timber of the same class.

Though Totara has not succeeded in capturing the Australian market like Kauri, there could be little doubt of its doing so in the future, for three reasons—(1) The coming timber scarcity, especially of timbers in the class of durable softwoods; (2) the better Totara timber that will come from cultivated forest; (3) the much more economical working from accessible, well-roaded, cultivated forests, and so a lessened price in future. Timbermen have assured me that in the great forests of Totara still remaining in the middle of the North Island there are Totara trees that in growth and stature are the equals of all but the largest Kauri trees. Black-pine, though relatively scarce and less durable than Totara, is of importance.

Rimu, the Red-pine of the South, the national timber of New Zealand, occurring throughout the length and breadth of the Dominion, is too well known to discuss here. When creosoted it furnished a fair railway-sleeper, though the penetration of the creosote was not quite the best, and the wood was too soft for heavy traffic. It is second only to the Kauri and Totara in economic importance, while it is more widely and evenly distributed. It will flourish on poor soil, as on the West Coast, where it is the largest and most abundant timber tree. In the North Island forests it is often held to indicate poor soil. Its rate of growth may average about two-thirds that of Kauri: its natural regeneration perhaps 80 per cent. that of Kauri and 40 per cent. that of Totara. It seems less able to persist under shade, and less able as a seedling to stand full exposure than Totara. Red-pine (*Dacrydium cupressinum*) is described in Kirk's "Forest Flora," but not in Cheeseman's "Illustrations of the New Zealand Flora."

Puriri (*Vitex lucens*): Campbell-Walker thought that Puriri would repay expenditure "on reproduction, natural and artificial, perhaps better than any other indigenous tree." He noticed its usefulness as a soil-maker in Kauri under-forest. Its habitat extends somewhat farther south than Kauri. Puriri-borer, however, might be worse in cultivated forest.

Puriri is a somewhat cross-grained durable hardwood, and the point to determine is whether, allowing for its greater silvicultural value, it can compete with Tallow-wood and some of the first-class Australian Eucalypts as a producer of durable hardwood for sleepers in the north.

BEECHES (*Fagus* spp.).

The great Beech forests of New Zealand are similar to the Beech forests of Europe. *Fagus fusca* in its durability, and one or perhaps two others as well, are better than European Beech. New Zealand Beeches grow somewhat faster than the European Beech, otherwise silviculturally they are similar. Like the European Beech, they are of secondary value as timbers. Where the New Zealand Beech (Birch) forests fail is in not having a valuable timber, such as Oak, associated with them. This valuable timber remains to be introduced. Its introduction in planted strips, as I have frequently pointed out, is one of the primary objects of the New Zealand forestry of the future. Beech in New Zealand generally occupies a soil too poor, or a climate too harsh, for the "mixed" forest.

The chief use for Beech in New Zealand should be for railway-sleepers, but it is said to take the creosote badly, and to season badly.

The Beech forests will probably be demarcated into three classes—

(1.) Mountain pastures over 2,000 ft. or 3,000 ft. altitude.
(2.) Firewood and fencing-pole coppice, with ultimately planted standards.
(3.) Good Beech forest, to have planted strips of valuable self-spreading timbers.

Ash is the only European timber which has not got its counterpart in New Zealand. Several species of Ash and Hickory remain to be put into New Zealand forests when New Zealand forestry comes by its own. Hickory and, in a more marked degree, Ash grow easily in New Zealand —in fact, better than in Europe; so here again New Zealand forestry can leave European forestry behind. In the United States the average value of Hickory sapwood is double that of Oregon heartwood!

For beautiful timbers there is little in Europe to compare with the common New Zealand Honeysuckle (*Knightia excelsa*), and nothing to equal the sheen and figure seen in waved and mottled samples of Totara and Kauri. The European truffle-yielding Oak has its counterpart in the New Zealand fungus-yielding Karaka.

Here the comparison ends, and New Zealand can then throw into the scale small quantities of such useful secondary timbers as the Olives, Kowhai (*Anglice* "Go I"), "Broad-leaf," Mahogany (*Dysoxylon spectabile*), Pukatea (like South African Stinkwood), and several others in lesser degree. A forester's impressions regarding these and other native trees of New Zealand will be found later.

It is easy to imagine what may be the value of the New Zealand forest when it has had 150 years' cultivation like European forests, and when such valuable specially quick-growing trees as Puriri have become largely increased in proportion to other species. This has been the case with Oak as against Beech in Europe.

With the peerless Kauri in the most northerly forests, and the noble trees of Totara in the next forests, there can be no question of the high economic value of the northern forests of the Dominion. Happily, though there is only comparatively a remnant of good Kauri forest left from the dark days of New Zealand's history, Totara forests of great value and extent remain to be demarcated. Thus the "balance-sheet," prepared above for the Kauri forest, will be applicable, with but little reduction, to a large part of the forests in the northern half of the North Island. Nor will it be difficult to make the reduction required for forests of lesser value, but still valuable enough to be treated intensively.

Two points remain to be noticed in the "balance-sheet": (1) Age-classes, (2) milling.

AGE-CLASSES AND YEARLY CROPS.

The forest will be fully stocked, at the first or at the second fellings, in from 20 to 40 years from now. When the first full timber crop comes to be taken out, from 60 to 100 years hence, the main problem facing the foresters of those days will be that of the age-classes.

In this 60 to 100 years' period the growth in the different sections of forest will have varied. That variation, together with early and postponed cuttings, will enable the foresters to scheme out the age-classes. Once the age-classes are established it will mean regular yields from one part or another of the forest every year, exactly as there are yearly crops from a farm. It should perhaps be explained that the figures in the "balance-sheet" are general averages for each forest or "working-circle" of a forest. They will not be true for any one section or compartment. They view the forest as a whole. At one time there may be revenue in one section and expenditure in another. Thus in the cultivated forest the balance is struck yearly: there is no interest charge as in the case of forest plantations. To think of destroying the forest and replanting it is reckless extravagance, especially in New Zealand, where both labour and the current rates of interest on money are higher than in Europe.

MILLING.

The "balance-sheet" shows that milling will go forward much as at present, the intervals being—for the main crop, about 100 years; for the thinnings, from 20 to 40 years. The forest being cut up with a complete network of roads, the milling-conditions will be much easier than at present. Earlier thinnings before the road network is complete can be arranged to be put through in groups of sections abutting on existing roads or tramways. Generally speaking, the foresters will not make thinnings that do not pay, and the want of them will be less felt in this class of forest than in some others, their place being often taken by *nettoiements* and ring-barking (p. 116). In the New Zealand "bush" the analogy is with the coppice-under-standard system of regular forestry. The main thing during the "transition" period is to look after the standards, averaging 200 to 300 to the acre.

FARM-VALUES AND FOREST-VALUES COMPARED.

For the State it is important to see clearly how these returns from State forests compare with grassing and dairying or other pastoral values. In what goes before I have taken two concrete cases as illustrations: the Puhipuhi land with the forest destroyed and taken for grassing and dairying (p. 57), and the Waipoua Forest, with the land on three sides, taken for grassing and dairying ("Waipoua Kauri Forest," pp. 46–48). To fully realize what these forestry figures mean one may lay them alongside average pastoral-farm values. They compare favourably with even the present inflated land-values, such as land-sales of farm land at Taranaki that within the last two years have touched £100 per acre!

Taking a good cow as yielding £20 per year gross and an average cow as about £12, I have good authority for the following as a rough average scale of dairy values:—

PASTORAL VALUES OF LAND.

	£
First-class grazing (Taranaki, for instance) carrying one cow per acre	80
Good land—one cow to 2 acres	40
Fair land—one cow to 3 acres	27
Poor land—one cow to 5 acres, or two sheep to the acre (hills around Wellington, for instance)	16
Very poor land—one cow to 10 acres, or one sheep per acre ...	8

From here there are all values of miserable and unsuccessful pasture. They need not be considered against forestry values.

Passing over good land and fair land with one cow to 2 acres or 3 acres, with 5 acres per cow we have 40 cows on 200 acres, or 40 × £12 = £480 gross earnings on a 200-acre allotment, or *£2 8s. per acre.* For the net profit, as it costs £8 or £9 to keep a cow, for labour and other expenses (so say the dairy experts), this leaves £3 or £4 (say, £3 10s. as an average) per cow net profit. So that, in the case of poor grazing, at 5 acres to the cow, with cows of average value the net profit is, say, £3 10s. ÷ 5 = **14s. per acre.** Any forest in fair order will yield something like this now, and much more hereafter.

Men who do forest demarcation must have a practical knowledge of both farming and forestry capabilities.

Two Forest-demarcation Values.

It may be noted here that in forest demarcating two values have to be considered, and how far possible loss on the first value will be compensated by perpetual gain in the final value.

(1.) Timber value of forest worked by foresters (less costs of timber-working aiding natural regeneration and interplanting where required) for about a hundred years against farmers' pastoral value for the same time.

(2.) The eventual return of £10 16s. net per acre per year for Kauri forest (other forests proportionately less) against the farmer's pastoral values as before. Thus, from twenty to about a hundred years the farmer can compete with the forester. After that, in the case of good forest, the farmer with even his best dairying is left behind. It is a position that many will not be ready to accept without a careful examination of the figures.

The exact amount of competition that the dairy-farmer can get in depends on the present state of the forest. Against a forest with mostly old timber, or with no young timber to come forward, he can compete for about a hundred years, with every advantage on his side. Against an ordinary forest with timber of all ages represented, as contemplated in the "balance-sheet" above, he can compete on fairly even terms for about a hundred years. Against a forest with the young age-classes well represented his chance will not extend beyond twenty or thirty years. Of course, I am speaking now of demarcated forest where the soil is not the best, but has sufficient depth to carry a fair timber-growth.

Employment.

So much for money returns. As regards relative employment and land-settlement the case is similar. Where the forest is poor, dairy-farming will afford more employment for the next hundred years; after that ordinary dairy-farming will rarely equal the forest rate of one man per 75 acres. Where the forest is young and of good quality the dairy-farmer may be left behind in close settlement even now. Against grazing other than dairying—viz., sheep or cattle—the forestry prospect must be very poor indeed—in fact, quite extraordinarily poor—for sheep or cattle runs to afford more employment than forestry. The case for forestry is stronger under the head of employment than under the head of *direct* money returns.

NATURAL REGENERATION.

Assuming that there are sufficient old trees on the ground to produce seed, natural regeneration may be summed up in these words: *Light, and the soil in good order*. Primarily it is a light-study.

When, as a green boy, I was sent to study forestry under a French Conservator of Forests, his first lesson was a tour round his series of *coupes* (felling-areas), beginning with little light and few young trees, and ending with full light and the ground sufficiently covered with young trees, though not in the regular state that an amateur forester might expect to see. These regeneration cuttings may last from ten to thirty years.

How to get it.—In nature an old tree falls and lets in light. If there is dormant seed in the ground (or on the fallen tree) and if *the soil is in good order* there will be an abundant crop of young trees, but otherwise not. There is a balance of influences for and against natural renegeration; and in the end the forest remains as it has existed for ages.

It makes little difference if man steps in and fells the old trees a few years earlier, leaving the rest to nature as before. This is *jardinage*, or "selection" felling. It makes more difference if the forester, after a close study of natural forces, intervenes more vigorously, the forester's object being usually to regularize the forest so as to get even-aged timber crops, and to secure fellings concentrated in one place at one time. *Jardinage* more or less systematized is usually applied to inaccessible, poor, or exposed forests. It is often a step to the regular "shelterwood-compartment" forest. With *jardinage* natural regeneration is as certain as in the virgin forest. To pure *jardinage* most foresters prefer to add some "improvement fellings" and cultural operations, as far as the accessibility and, consequently, value of the forest will allow.

Sir William Schlich, after the tour of the English Arboricultural Society through the German forests shortly before the war, summed up natural regeneration in these words: "Natural regeneration is only possible if the soil is in proper condition, or if it is worked. The great object always is to avoid the cost of working the soil by seeing that it is kept in good condition. Natural regeneration is generally, though not always, cheaper than sowing or planting; but, above all, the shelter-wood with natural regeneration prevents the soil from deteriorating during the regeneration period."

Letting in the light, of course, means felling the timber. The forester marks the trees for felling always with a view to natural regeneration. In technical forestry special rules are laid down for carrying out the regeneration fellings. There is a system of cuttings called *coupes de regeneration*, ending with the *coupes definitives* when natural regeneration has been secured, and the young trees are able to stand a full exposure to light.

In most forests of true Pine (*Pinus* species), or in any other forests where natural regeneration is good, such as the Beech forests of New Zealand, or below the Oaks and Sycamores in the parks at Christchurch, or in much of Mr. Deane's fine plantations at "Homebush," all that is required for natural regeneration is the removal of the older trees, though it is usually not safe to do this in one operation, as the soil would deteriorate, and a too sudden exposure to full light, to sun, and to wind would harm the young trees.

As mentioned in "Waipoua Kauri Forest," in two places where the old trees have been removed there are enough young Kauri trees on the ground to easily replace them—eight or ten young trees for each old tree cut. Where this usual way of producing natural regeneration fails, one or other of the means indicated below would be considered by the "working-plans" forest officer.

Discussing natural regeneration of Kauri in Auckland with those who have known the Kauri forest all their lives, the consensus of opinion is that natural regeneration is sufficient for practical purposes. I feel sure that if those who hold the contrary view could visit the cultivated European forests under skilled guidance they too would be convinced. The visit must be under skilled guidance. I have known visitors who had been to forests where natural regeneration was nearly universal come back and tell me they had seen all the forest operations from planting to felling. What they had really seen was some little planting where natural regeneration had failed, or where there was some special provision of the working-plan requiring it.

Sàl (*Shorea robusta*) is an important Indian forest-tree. Its natural regeneration, however, is not good enough to satisfy foresters. Now, what did the Indian Government do? It did not proceed to burn the forest, which is rather like hanging a man because he has got a sore throat. It made a scientific investigation of the matter, and the results of that investigation are recorded in "Indian Forest Records," vol. 5, part 4. (Government Printing Office, Calcutta; 1s. 7d.)

Similar reasons, a too dense undergrowth, prevent abundant natural regeneration in most of the "mixed forest" of New Zealand. This subject will be discussed more fully in Part II.

MEASURES FOR AIDING NATURAL REGENERATION.

(1.) "*Nettoiements*" *and Improvement Fellings.*

This is cutting or ring-barking trees of inferior species, and thus making the covert (shade) less dense for the better trees. It would include cutting Nikau-palms, Tree-ferns, and in places brushing.

Beech is girdled in central Europe when there is no market for it, to prevent it dominating Oak. Girdling (ring-barking) heavy timber in Australia is done for 3s. or 4s. an acre. Ring-barking is not in favour with the Marlborough (Waipoua) settlers, because the trees are apt to die too slowly, but in forestry where the object sought is to reduce the covert it will generally be sufficient to stunt the trees. New Zealand ring-barking should be more economical but less effective than that of Australian hardwoods, where the heartwood is usually dead matter, so that when the sapwood is cut through the tree dies.

Nettoiements is a French forest term for thinning out inferior species, though in the case of older trees it is included in "improvement fellings." It is evident that there is much of this work to be done in the Kauri forests. In the course of discussions with Ranger Maxwell on the subject of Kauri reproduction I have explained *nettoiements* to him. His opinion is favourable as regards the practicability and usefulness of this work, but he has fears that it might lead to fire. That is a matter of organization (p. 145). With the forests organized as explained later I should not have much fear of fire.

An American forester, in *Journal of Forestry* for May, 1918, has described *nettoiements* in a regrowth Strobus pine and "leafwood" forest. The work was difficult, since the pine there has only a third or a fourth the growth of the "leafwoods." Yet the cost, £1 10s. per acre for two *nettoiements*, comes out much the same as the usual two unremunerative thinnings in pure forest. Some American foresters use the term "liberation cuttings" for *nettoiements*.

Advance "Nettoiements"—In ordinary French forestry *nettoiements* are made to free and clear existing valuable *regrowth*. But the question has presented itself to me whether *nettoiements* should not be adopted as a general measure near seed-bearing trees of Kauri, Rimu, Totara, Puriri, and White-pine, wherever there is a chance of getting natural regeneration, and where it does not now exist; so as to start the forest earning something at once. (The wild forest, as we have seen, earns nothing: growth balances decay.) Then, when the regular timber-cuttings came to be made later, the young trees so produced would form what foresters term "advance growth." There is much Tree-fern, Nikau-palm, undergrowth, and comparatively worthless trees, such as Towai or Kamahi (*Weinmannia sylvicola*), now occupying ground and earning nothing! Nikau-palm seems particularly easy to chop with an axe, but the bushmen tell me it soon comes up again. Its low, dense cover marks it out as more unfavourable than perhaps any other influence to Kauri regeneration. I anticipate that the result, in Kauri natural regeneration, would repay the cost of *nettoiements*, even after allowing for some inevitable destruction of young Kauri when the old trees come to be worked. (See p. 87, "Mid-rotation Fellings of Kauri.") This is a matter for experiment, and the detailed study put into the "working-plan." With *jardinage* the removal damage would be less than with the normal "shelterwood-compartment" system. Natural regeneration in strips and groups (p. 122) would also reduce it.

To repeat for clearness: In the ordinary course of forest-working a *nettoiement* would be done only after the first timber-fellings (the seedling cuttings of foresters) had passed—*i.e.*, where the forest was in process of regeneration and there would be no more felling of trees for some years. But the forest at Waipoua, and much other Kauri forest, is so understocked with Kauri and the first-class timber-trees that I am of opinion that these *nettoiements* should be undertaken as a general measure *preceding, as well as following*, the regular regeneration cuttings. As mentioned, in much of the present Kauri forest the average of mature trees will be barely one per acre, even in the so-called Kauri zone, while there are many parts of the Kauri forest where there is not more than one mature Kauri to 10 acres. Under these circumstances the natural regeneration of Kauri can only be very slight, and it is advisable to take measures to get in a stock of young Kauri as soon as possible. These measures might include both *nettoiements* and some interplanting with it. Both of these would be excellent light work for returned soldiers. Much work like this, but less useful, has been done in Australia ("Australian Forestry," p. 367).

(2.) "*Wounding*" *the Soil.*

Roughly raking or breaking the ground with a heavy long-handled hoe round the branch-spread of an old seed-shedding Kauri or other valuable timber-tree. The expressive French term is "wounding the soil." In Europe this is commonly prescribed in the "working-plans," and I have often seen marvellous results produced by it—the seed prodigality of nature turned to account. Without it the layer of ground vegetation, moss, raw humus, and dense shade on the forest-floor may stop all seed-germination under old trees for centuries. Then at last the old tree crashes to the ground, and the bar to natural regeneration that has existed for so long is lifted—perhaps just long enough to produce a dozen seedlings!

"Wounding the soil" is done as a matter of course whenever timber is worked—hauling logs and the tramping of animals and men. Hence much of the utility in the successive "regeneration fellings" of scientific forestry.

I have practised "wounding the soil" in the New Zealand class of forest in Africa. It was successful as long as we were able to hit off trees bearing seed well, before the cleaned and broken ground got grown over. It has the best chance of success where there are well-marked seasons, with the trees shedding their seed in autumn and little regrowth of the ground vegetation till spring.

"*Gum-diggers*" *as Helpers.*—The Austrians who now do the greater part of the "gum-digging" appear to be a fine body of men—Dalmatian peasants, hardy, frugal, and industrious. They have, as regards the forests, been charged with lawlessness, but people can hardly be called lawless in a country where there are no adequate forest laws, and where there are scarcely any Forest Rangers to look after the forest. It is easy to see that as soon as the forest is organized these men may render most valuable service. Their business is to turn the ground over in search of Kauri "gum"; the business of the Forest Department is to get it turned over by hand, so as to favour natural regeneration and lessen the cost of artificial regeneration. The Waipoua Forest at one time was full of "gum-diggers." They had to be turned out when the forest was closed for preservation. As soon as the forest is opened for working, developed with roads, and in charge of an adequate protective staff, the "gum-diggers" will be welcomed. There is an unknown value of Kauri resin in the ground; the diggers would pay current rates to the Forest Department for working it, and all the ground they turned over would be utilized for forest regeneration.

Some useful work might also be obtained from the "gum-diggers" as forest cultivators.* It would enlist the well-disposed in the police work of the forest, and get a little costless planting done where it might eventually be very useful, such as with self-spreading good timber-trees.

(3.) *Fire as an Aid to Natural Regeneration.*

In forests where there is a dense undergrowth fire is a most important aid to natural regeneration. It brings up the dormant seed in the ground, and it gives the forester his chance for easy planting or "wounding the soil." I am inclined to think that in the future management of the Kauri forests fire (of course, under control) will play a large part in restocking the forest.

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* "Forest cultivators" are men who, under temporary permits from the Forest Department, are given temporary homes in the forest. They burn off patches of worthless bush and raise crops, planting trees in the ash-fertilized ground. As the fertility of the soil declines and the planted trees grow up they pass on to fresh ground. They are given other forest privileges, and act as local helps to the Ranger in charge. Forest cultivators often do very useful work. The bad ones quit at short notice. Like "gum-digging," the position is sometimes a refuge for alcoholics and sometimes for those who are merely nomads.

In the regeneration of the Australian Eucalypt forests usually all that is required is one good fire and fire-protection afterwards. Full details are given in my "Australian Forestry."

In southern Europe when the pine forest is burnt young pines come up like grass from unopened cones and dormant seed in the ground.

Again, in the great forests (three or four million acres) of Chìr-pine (*Pinus longifolia*) in the Himalayas, where the climate in the wetter parts, and the latitude, are similar to Waipoua (*Dodonæa* and *Myrsine* are common shrubs there, as they are in New Zealand), "the burning of the soil-covering, and particularly of the thick layer of undecomposed needles, in good seed years, is a regeneration measure of decided value if it can be carried out with safety: this would include the cutting and burning of undergrowth and the collection and burning of debris where necessary" ("Indian Forest Memoirs," Vol. 1, Part I, p. 51). This is an authoritative statement from the pen of Mr. R. S. Troup, F.C.H., whom I know personally, and who is now holding high office in the Indian Forest Service—Assistant Inspector-General.

In forest more like that of New Zealand than pine forest, we read that the natural regeneration of Sàl is improved by moderate burning in the forests of the Terai; while it is destroyed by repeated burning (Burkell, in *Journal of Asiatic Society*, September, 1916, p. 267). This is in dense forest with a heavy rainfall, the latitude and climatic conditions in the upper part recalling almost exactly those of Waipoua.

Says Mr. Troup in a recent letter to me, "In the damp Sàl forests of the Duars of Bengal and Assam, continued fire-protection has induced the growth of a dense evergreen undergrowth, which effectually prevents the establishment of young Sàl. We are now considering special measures for regenerating these forests." These words might be used in describing the present position in most New Zealand forests.

In all these cases we see the truth of the old saying that fire is a good servant but a bad master. The use of fire will have to be long and carefully studied when foresters take in hand the natural regeneration of New Zealand forests. Atkinson Park (so called, really a Kauri forest), near Auckland, was worked, burnt, and then protected from fire by the interest of a local resident, Mr. Atkinson. The good natural regeneration of Kauri there is referred to in "Waipoua Kauri Forest."

In the Waipoua Forest there will be little difficulty in keeping fire under control—in fact the difficulty will be in getting a good burn. In other Kauri forests fire can be used more easily.

A Good Seed Year.—Kauri, like all other trees, bears seed much more abundantly in certain years, but there is never a great abundance of the seed. The Longifolia-pine, in its climate like north New Zealand, has a good seed year on an average about every third year. In northern France the forester has sometimes to wait eight or ten years for a good Oak or Beech seed year (*glandée*). When that comes he is busy with every method known to him for favouring natural regeneration. After a good supply of seed the first requisite is a clean soil. Temporary grazing will help that. Fire will help it more.

In the one good State forest of England, the "Forest of Dean," visitors go to see a piece of show natural regeneration of Oak at Blakeney Hill. It is literally a sheet of young Oak. That came about in this way. It had been grazed bare for years. It was then closed to grazing, and a heavy seed year on the old Oaks occurred just afterwards.

(4.) *Grazing.*

Grazing in cultivated forests, *at the right time and in the right quantity*, is often an important adjunct to natural regeneration. It is frequently referred to in forest reports from India and in accounts of European forest inspection tours. I have elsewhere ("Waipoua Kauri Forest") suggested the introduction of the south European tame buffalo to Waipoua for log-hauling. One can imagine how well the ground would be got into good order for natural seeding after the partial removal of Kauri timber, the Kauri grass, the Kiekie, and the rank ground herbage eaten off by the buffaloes, and the ground broken by their ponderous tread!

It is stated on good authority that Kauri is so full of resin that cattle will not touch it. I have never seen it eaten by cattle. This is an important point in favour of Kauri. It may be set against its liability to fire, which has been a good deal exaggerated, often from interested motives.

I think it may be accepted that, like Blue-gum and some other strongly flavoured trees, cattle will not readily eat Kauri, so that with light grazing in the forest where cattle are free to "choose their bite" they will leave Kauri alone, while clearing away the troublesome ground herbage.

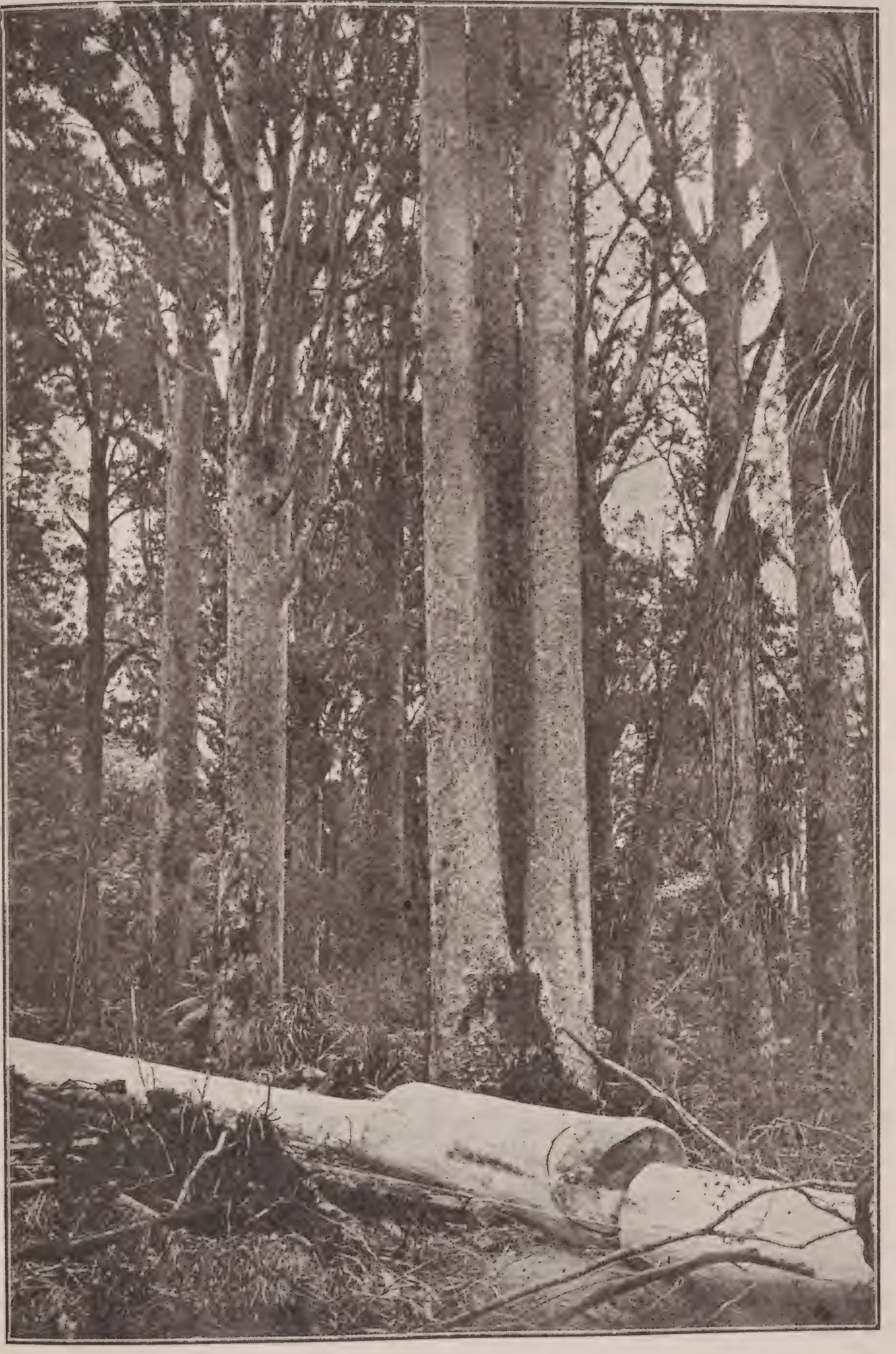
In India forest grazing is of the first importance. Forest grazing there and in New Zealand latitudes in Europe is fully discussed in "Australian Forestry" (Perth, 1916). There is no doubt, as mentioned in the inaugural address of the Forest League, that one of the results of developing the mountain-forest lands in New Zealand will be to provide much grazing for domestic animals of every kind. Fourteen and a half million animals —cattle, buffaloes, goats, and sheep—grazed in the Indian forests in 1913–14. The grazing is regulated so as to close forests against injurious cattle during the regeneration period ("Forestry in India," MacMillan, Forest Quart., December, 1916).

(5.) *Coppice Reproduction.*

Kauri stumps will occasionally send up coppice shoots, but they are of little use for natural regeneration. That is the general opinion, but a case was reported by a Forest Ranger in the Puketi Forest of fifty or sixty cut Kauri trees having coppiced into well-grown Kauri rickers. Most likely the cut trees in this case were quite small ones. There is no doubt that Kauri will reshoot when young after being cut or broken. That Kauri can coppice when young is shown by the not very rare occurrence of two or three trees on one stump. This is well seen in the photo opposite (Plate XV). The cutting-back to the ground-level of badly grown, diseased, or broken stems is constantly being done by the French forester —*recepage*. His sharp draw-knife is always in his hand or pocket. The practical effect is to substitute a good young tree for a bad one. The root of a seedling or sapling is out of harm's way, but the part above ground has to run the gauntlet of many dangers, especially with timber-working, before it is grown up and fairly out of harm's way.

Most of the other timbers growing with Kauri reshoot when young, and of some of these the reshoots of trees up to 1 ft. or more diameter are strong enough to form good trees again on the same root. Puriri and Mahogany (*Dysoxylon*) I have noticed doing this; indeed, these trees grow like Willows from cuttings in the damp ground of the forest, and it may be quite practicable to propagate them, on a large scale as with

PLATE XV.



KAURI: THREE SHOOTS ON ONE ROOT.

Photo, A. J. Northwood.]

[*To face p. 120.*

Willows, by simply inserting stakes or sticks in the ground. I have seen a pole of Mahogany placed across a stream in the Waipoua Forest, forming part of a rustic bridge, that had sent up strong shoots from each end where it rested on the ground!

Cuttings.—I understand from a nurseryman who has grown Kauri for some years that Kauri cuttings do not strike freely, but cuttings are rarely of much account in forest nurseries. Puriri, Mahogany, and many of the introduced trees could be propagated on a larger scale from cuttings if desired.

(6.) *Pigs.*

L'introduction des porcs, or the running of pigs, is a regular measure for favouring natural regeneration in French forests. I saw much of this during my forest training in France. Pigs turn over the ground and favour the germination of the seed. They "wound" the ground at no cost to the forester: indeed, frequently in Europe he is paid for the right to run pigs. This useful action has been remarked by American foresters studying natural regeneration of the Short-leaf Pine (*Pinus echinata*). Says a recent Forest Service bulletin (1915), "The hogs consume practically all of the Oak and Hickory seed, and at the same time prepare excellent seed-beds for Short-leaf Pine by uprooting soil and humus in the fall of the year."

The pig industry should thus be encouraged in all those parts of the Kauri forests that are under regeneration, and probably in practice almost everywhere. Pig-raising in the Waipoua Forest is already a profitable business. I had to do with the slaughtering and eating of a forest pig when I was at Waipoua. With precautions the pigs do not get out of hand. It is a lucrative industry, and might be developed to rival the running of sheep on deforested ground. In Portugal, in New Zealand latitudes and climates, the fattening of pigs running in the forest is of national importance (*vide* "Australian Forestry," pp. 62, 263). One-third of a million pigs are fattened yearly in little Portugal on acorns and forest-products. The industry quite compares with sheep-raising in open country; but, taken with the forest work, supports much more population. Portugal has about the same population as Australia on a smaller and much less fertile area than New Zealand. Pig-grazing can, of course, be carried to excess; it has to be watched by the foresters and stopped if this point is ever reached.

In New Zealand there are under one-third of a million pigs altogether (284,000 in 1917); and the increase has only been *5,869 during the last thirty-one years.* (A. Macpherson, *Farmers' Advocate*, 7th September, 1918.) They are practically all sty-fed pigs on the English model, though I know a few farmers—notably Messrs. Davison and Deans, of Canterbury—who run their pigs in their Oak plantations. The industry badly wants the push which forestry in New Zealand would give it.

(7.) *Spacing.*

When a crop of Kauri seedlings has been produced naturally or with the help of the above measures, spacing—viz., transferring them artificially—is not difficult. A planting-spade or a sharp-nosed miner's shovel is employed. I prefer the latter. The long-handled New Zealand shovel would do better than either. The young trees are taken out with a large clod of earth round the root, transferring them to where the forester wants them, at no risk and little expense. Seedling transference done in this way does not disturb the roots, so that the trees grow without check *till mulching-age* (p. 133), when the danger of being smothered by ordinary ground herbage ceases with the mulching. In the course of a day a man will in this way space and transfer a large number of Kauri, Totara, or other seedlings.

Spacing may be used for extending the "groups" of natural regeneration in the "group" system (p. 79). There may be a great deal of spacing to be done in the cultivated forests of the future in New Zealand. I have practised it for many years in South Africa.

(8.) *Tea-tree, or Manuka.*

Encourage the growth of Tea-tree (*Leptospermum ericoides* and *L. scoparium*) wherever this is abundant near old Kauri trees. Mr. Cheeseman, Dr. Cockayne, and other travellers in the Kauri forest are agreed as to the important function Tea-tree performs in acting as a nurse for Kauri. Keur (*Virgilia capensis*) performs the same function in South Africa—the *bois blancs* of French forestry, in France. Tea-tree will generally come up after a fire. Its reproduction can be rendered certain by scattering a few Tea-tree bushes over the ground and firing them.

(9.) *Cutting-areas.*

Making the *coupes* or cutting-areas in long thin strips. This is a common practice in Europe (see above, "Sihlwald Forest," p. 79, also "Group System," p. 79); in fact, European forestry consists chiefly in arranging the cuttings so as to ensure natural regeneration.

(10.) *Preparing the Forest-floor for Seeding.*

The Forest Rangers would be on the lookout for good seed years of Kauri, Totara, &c., and get the forest-floor ready against the fall of the seeds by grazing, brushing, hand-hoeing, pig-grazing, or fire. It would probably take several seed years before they got a complete natural regeneration, and in the end some planting or seed-sowing might be required to complete it. The forester's great chance is when the forest-floor is prepared for him by accidental fires. This fact stands out in strong relief when one goes over the strips of forest burnt at Waipoua in the great fire-year twenty years ago. I hope such another chance will never again be lost.

There are exact records of the seeding years in forests under cultivation, as in Europe, India, America, and Japan. There is a little seed every year; but the years of abundant seeding (*glandée* in the Oak and Beech forests of France) occur at intervals of two or three years.

Kauri is classed silviculturally as somewhat "light-demanding," so it may require the forest well opened for a seedling felling, and it will probably be found that Kauri can stand the covert being taken off in one operation afterwards. Usually two are required.

THE TECHNIQUE OF NATURAL REGENERATION.

Details will, of course, be found in the text-books.* The American definition of natural regeneration for the normal even-aged forest runs,

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* U.S.A. Forest Circular, "Reproduction of Western Yellow-pine," 1910, gives in an appendix the official instructions for the marking of a *coupe* or felling-area in a mixed forest of Ponderosa-pine, Douglas-fir, and others of the introduced trees grown in New Zealand; the first object being to secure the natural regeneration of the forest, the second to facilitate the milling of the timber.

"That method of conservative lumbering in which reproduction is secured from self-sown seed by means of successive cuttings made throughout the mature stand, thus leading to the production of a new stand of timber approximately even-aged. These successive cuttings encourage seed-production, create conditions favourable to the growth of seedlings, and gradually remove the remaining trees of the mature stand as the young growth develops." ("Terms in Forestry," Bulletin No. 61 of the Forest Service, p. 23, Washington, 1905.)

To obtain a general idea of the subject, I give three sketches here of natural regeneration—(1) in the Chìr forests of northern India, nearly the latitude and climate of New Zealand; (2) in Europe; (3) in South Africa, with forest similar to that of the Kauri forests.

Himalayas.—A recent publication, "Indian Forest Memoirs," is a work of merit, entitling it to be widely read in New Zealand. The author, R. Troup, is a forester of repute. Chìr (*Pinus longifolia*) has been very successfully planted in South Africa, but only on a small scale. It withstands bush-fires.

For the natural regeneration of Chìr growing in its great forests on the lower Himalayan slopes, in a climate similar to Waipoua, Mr. Troup has formulated these four natural-regeneration rules summarizing the experience of Indian forest officers during the last forty years:—

(1.) In felling-areas leave five to eight trees per acre of large trees with well-developed round crowns. If the available trees are smaller leave more.

(2.) Thinly scattered small trees and poles should be felled in order that their place may be taken by denser regeneration growth.

(3.) Well-stocked groups of small poles should be left to form part of the regrowth forest. They should be freed from overhead covert.

(4.) Inferior species, and unsound or badly grown trees of the superior species, should be marked for removal.

To these four seed-felling rules for Longifolia-pine might be added, for the Kauri forest: Where it is desired to get rid of the inferior species, fell in summer at the driest time of the year; where the reshooting of good species is wanted, fell in winter.

Europe.—The late Captain Campbell-Walker, known for his report on New Zealand forestry, in a previous report by him on European forests (Parliamentary Library, Wellington), comments on the success of natural regeneration in France. It has been practised there for many years, and results, at all ages, may now be seen. Natural regeneration, he says, has succeeded better in France than in Germany, and he ascribes this greater success to the damper climate of France, all of which is in favour of natural regeneration (as understood by foresters) in New Zealand.

In Europe, in the latitudes of New Zealand, the regeneration is generally natural, with the notable exceptions that Scotch-pine is planted and the fine Spruce forests of Saxony still have mostly artificial regeneration. In Saxony it is quicker than natural regeneration, and some years back could be done for £1 per acre. Labour was then one-fourth the present price in New Zealand, and the peasants paid about £1 an acre for the right to cut the grass in planted areas; so that in practice the replanting cost next to nothing!

Recent statistics show that in Baden, which may be typical of the South Island of New Zealand, less than 1 per cent. of the total forest area is artificial regeneration (see "Statistics," Appendix, Part II).

The general position in Europe is that the expense of artificial regeneration is only incurred when natural regeneration fails. But there are exceptions: thus, Oak is often sown; Scotch-pine, as above, is usually planted; but in Spain, in New Zealand latitudes (in the Royal Forest of La Granja), the natural regeneration of Scotch-pine is good. If Scotch-pine is ever going to grow in New Zealand this is where the seed should come from.

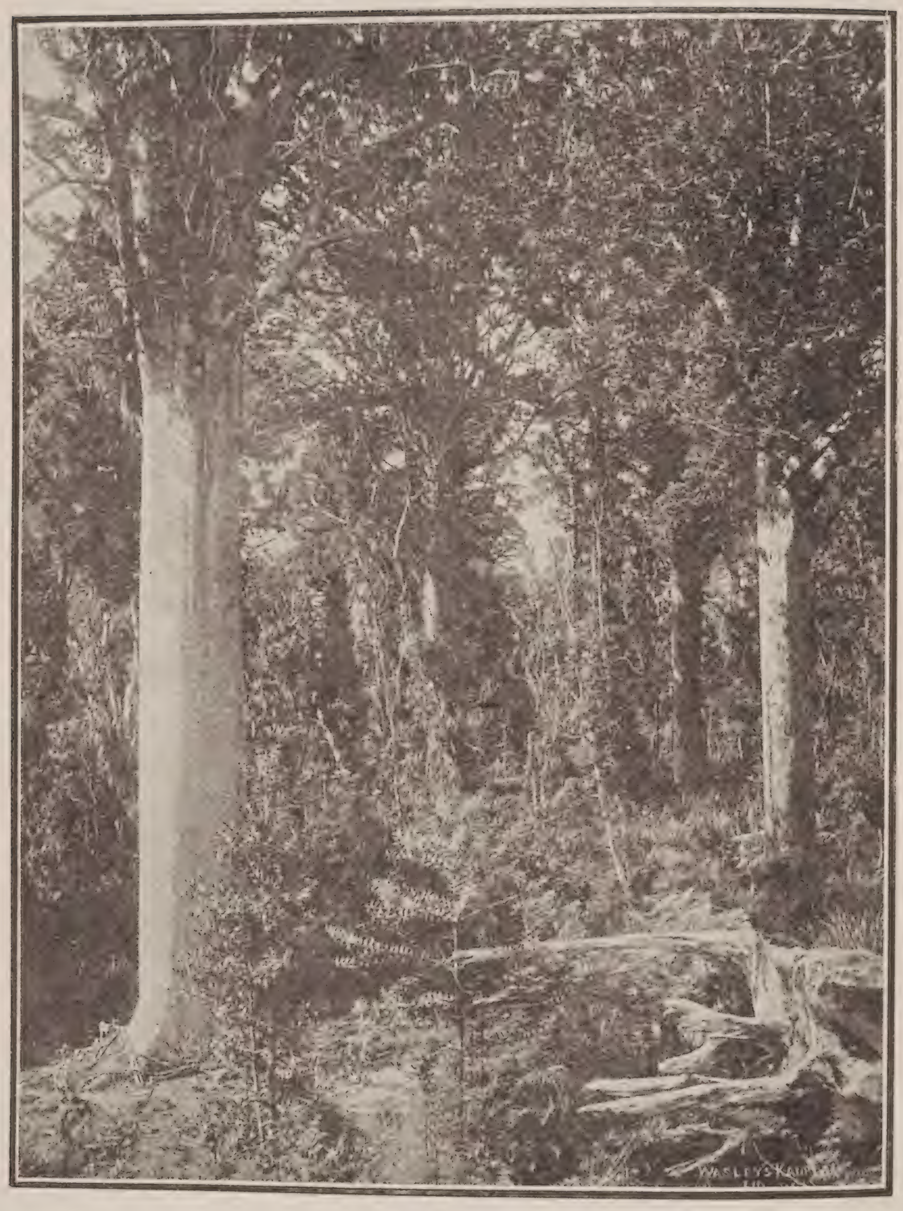
South Africa.—In the ordinary dense evergreen forest of South Africa, often called (after the chief species) "Yellow-wood forest," and which so closely resembles the "mixed" forest of New Zealand, I have seen areas that in twenty years had grown up from a hopeless-looking tangle of *bois blancs*, of bramble, and of fern to an area where there was a larger proportion of good timber-trees than in the primitive forest. On the other hand, I have seen "sections" of forest where natural regeneration had failed, and the area was no better or worse than the large mountain areas in New Zealand where grassing has failed, or not lasted, and the area run to scrub and become worthless. Such a result is, of course, deplorable economically. Generally speaking, the forester is in a much better position to prevent it than the farmer. In forest that it will pay to work intensively it should never occur. In forest capable of a net return of £10 per acre per year, such as Kauri, there is not the smallest excuse for it.

Mr. T. R. Sim, one of the most capable foresters the South African Forest Service has produced, has the following instructive note on natural regeneration in forests worked on the system introduced by the French forester Count de Vasselot in 1884—forests of exactly the same type, and in the same climate, as the Kauri forest of New Zealand. (Measures are now being taken to introduce the Kauri tree to them.)

> Most of the valuable trees are shade-bearers when young, but very few of them can stand heavy dense canopy; consequently virgin forest possesses almost no regrowth, while the more open a worked "section" is the better usually is the regrowth, especially of Yellow-wood.
>
> . . . All over-aged and decaying trees, as well as all thoroughly mature trees (*i.e.*, such as will not improve during the next forty years) are removed when a "section" is worked, except where large gaps are caused by so doing. Old or worthless trees that will not sell should be dealt with departmentally. Probably the revenue from this extra work would not cover the cost of doing it; but, even though it does not, investment in this direction is to be commended as much as investment in plantations, when it is kept in mind that the indigenous kinds are not easily raised in plantations, but that they reproduce themselves naturally under such treatment if given a fair chance, and that for many purposes they are to be preferred to the more easily raised exotics. The regrowth under a very open felling all comes together as even-aged material. . . .
>
> It has already been pointed out that indigenous trees do not readily spread on to new ground, and certain reasons have been adduced for that; but these do not hold with regard to the recovery of a cleared area, which, so long as it possesses its original stock of seeds and seedlings, recovers entirely, though rather slowly, if fire and trespass are prevented. Many beautiful examples of this are to be seen at the Perie Forest and elsewhere, in which forests, at that time apparently completely exhausted and wrecked, were closed by the Forest Department about twelve or fourteen years ago, and are now full of an abundant healthy and vigorous incombustible regrowth, much more important and valuable than the whole stock of over-aged and damaged trees without regrowth standing in other areas, apparently sound to the superficial observer, though actually in the last stage of decadence. ("Cape Forest Flora.")

A correspondent has asked if the large returns of planting from South Africa do not indicate that the native bush is regenerated by replanting. This is not so. It is safe to say that the trees planted in the native bush in South Africa do not form above 1 or 2 per cent. of the young

PLATE XVI.



KAURI REGENERATION

Three saplings in the foreground. Kaihotopu, Waitakerei Range.

Photo, J. Martin.]

[*To face p. 125*

trees that have come from natural regeneration. The planting is limited to the mere introduction of a few valuable species, and the planting of some patches of Wattles, at points where there is a risk of grass-fires getting into the bush. There should, in my opinion, have been more interplanting in the native bush in South Africa.

I make no apology for treating natural regeneration at some length here. It is a difficulty with many, who, comparing the New Zealand bush with other types of forest, have come to the conclusion that, apart from the Beech forest, natural regeneration is too weak to be depended upon for the continuance of the New Zealand forests. I hope I have said enough to show that natural regeneration in the hands of skilled foresters cannot be inferior to nature's work, but should be much better; and, as a matter of fact, is better in just so far as the forest can bear the cost of intensive working. The finances of the matter are discussed at p. 95, "Balance-sheet of a Normal Kauri Forest."

People have been heard to say that they did not believe in the natural regeneration of the New Zealand forest, because with untrained eyes they could not see it. They might as logically say they did not believe in the law of gravity! If they cannot see the one or the other, they can judge by results.

NEW ZEALAND OPINION ON NATURAL REGENERATION OF KAURI, ETC.

Campbell-Walker: a Forester.—"I was well pleased to note a fine growth of young Kauri interspersed with Honeysuckle (*Knightia excelsa*) coming up in this forest at Thames wherever fire had not followed in the wake of the bushmen."

H. J. Matthews: Convincing.—The late Mr. Matthews, Chief Forester, has recorded important observations on the natural regeneration of Kauri, which seems to have escaped attention. After inspecting various cut-out and burnt-out Kauri "bushes" visited in connection with the Scenery Preservation Commission at Puhipuhi, Waitakerei, and Whangarei he reports:—

> I found that wherever cattle had been kept out young Kauris were growing in abundance—from seedlings up to trees 6 in. and 8 in. in diameter. Near Cascade Creek, Waitakerei Ranges, I found young Kauris covering the ground as thickly as corn in a field. It was evident that large trees had been killed by fires many years previously—between twenty-five and thirty, I was informed. The largest trees (of the regrowth) measured a foot in diameter. I suggest therefore that immediate steps be taken to select recently cut-out Kauri bush areas for the purpose of ascertaining whether it is practicable *to re-establish forests naturally.* (Lands Department Yearly Report, 1904–5, p. 74.)

The last five words of this sentence read like Galileo's telescope being announced as a new discovery in the year 1917! I quote Mr. Matthews's observation because it should be convincing evidence for those who, like him, may question the practical use of Kauri natural regeneration.

After a tour in the great forests of the western coast Mr. Matthews reported: "In recently cut-out areas seedlings are appearing in countless numbers, but owing to fire and stock the majority of these perish." (Lands Department Yearly Report, 1906.)

Cheeseman: Opinion of a Scientist.—The author of the "New Zealand Flora" refers thus to the abundant natural regeneration of Kauri in an association of small trees often seen in the lower story of the Kauri forest—Toru (*Persoonia toru*), Tawhero (*Weinmannia sylvicola*), the White or large Tea-tree, the New Zealand Sandalwood, Celery-top

Pine, *Olearia cunninghamii*, Karamu (*Coprosma lucida*), Mingimingi (*Leucopogon fasciculatus*), and others: "This association often shelters multitudes of young Kauris, and if left alone would form an admirable nursery for a young Kauri forest." ("Illustrations," Plate 170.)

Mr. Cheeseman took me himself to see the Kauri natural reproduction in Atkinson Park, near Auckland, devoting an afternoon to the purpose; and he directed me to the even more striking natural reproduction of Kauri in Kauri Gully, near Northcote, Auckland. Speaking to the Mayor's party (Waitakerei Hills excursion, October, 1916), Mr. Cheeseman said that Kauri seed might lie dormant in the ground for ten or fifteen years or more, but the widespread and easy propagation of Kauri was mainly owing to the lightness of the seed. The cones open when on the trees, and strong winds spread the light seed far and wide.

Dr. Cockayne: Positive.—Dr. Cockayne, commenting on the ofttimes unsatisfactory natural regeneration of the best New Zealand timber-trees, says ("Forestry in New Zealand," p. 88, Lands Dept., 1909): "Kauri and Beech forests are an exception, the . . . trees in both cases coming up by thousands when the larger timber has been removed."

In his interesting account of the botany of Stewart Island (seemingly the second or third most important forest district of New Zealand), he says,—

> There is a deep-rooted popular belief that when the New Zealand forest is once interfered with, and the light let in through trees being removed, and so on, it is doomed. This opinion is one of those half-truths that arise from an imperfect acquaintance with the facts. It is true that forests do cease to be; but it is not merely the cutting-out of a certain proportion of the trees which has led to their destruction, but fire and cattle-grazing must be added to the destructive influences. . . . In Stewart Island, cut the forest to the ground, burn its last remnant to ashes, and in a very few years, notwithstanding the presence of cattle, it will reappear.

R. G. Robinson (Selwyn Plantations).—After a fire there is generally a fair regeneration of the native Beeches. This is well seen on the hills near Tapanui.

Ranger Maxwell: Interesting.—Ranger Maxwell, looking over the Waipoua Forest with me, has come to the conclusion that there is more natural regeneration now than there used to be in the Waipoua Forest, perhaps on account of the growing preponderance of aged trees.

Mayor's Party, Auckland.—At the Mayor's excursion to the Waitakerei Hills in October, 1916, when we went down into the forest it was easily seen that the Kauri reproduction, though superabundant in some places, was uneven and wanting in others. We noticed clumps of young Kauri standing at the rate of two or three to the square yard. The area required seedling-spacing (p. 121) and some seedling-introduction.

The Bushman finds enough.—In questioning bushmen and others who have known the Kauri forests throughout their lives I have generally found that the casual observers would tell you that there were no young Kauri trees, while more careful men would tell you just what they had seen of young Kauri, and that was often a good deal. I have more than once been told by bushmen that there were no young trees in certain Kauri forests—that the Kauri trees were dying out; it had been a fine tree in the past, but that its day was now over! Nevertheless, as soon as you went with them into the bush they would point out scores of young trees, and in patches a great many more young Kauris than were required to restock the forest.

Land Commissioner G. H. Bullard says natural regeneration in native forests is so good that if cattle and sheep are let in and afterwards excluded the young forest comes up again freely. He cites two recent cases at Taranaki.

Good Intentions.—There was an official wish at one time to utilize the natural reproduction of Kauri, and the writer of the chapter "Forests and Profligacy" in "New Zealand in Evolution," presuming the wish had materialized, wrote in 1909,—

> In view of the probable extinction of the Kauri forest within the next few years, the State Department has made a useful provision for the future by setting aside, and protecting against the depredations of fire and stock, areas of recently cut-out and abandoned forest. Young saplings spring up in abundance on the sites of old Kauri bush wherever natural enemies are removed. The State has taken over some of these areas as nurseries, and by clearing the dead undergrowth and keeping the undesired varieties of shrubs in check it is hoped in time to make a sound start in the reproduction of the Kauri forests which have been of such immense value to the State.

No one now knows anything about these good intentions. They were not carried out, and have passed out of memory.

On the West Coast.—Mr. W. L. Luxford, of Hamilton, an experienced sawmiller, described to me a case of natural regeneration of Rimu on the West Coast, where, on account of the wetness of the climate, it is difficult to destroy the forest by burning. Near Greymouth he was taken to see a fine young Rimu bush, estimated as running to almost 30,000 sup. ft. to the acre, with trees 1 ft. to 2 ft. in diameter and 40 ft. to the first branches. He noticed old cut stumps, and was told that fifty years ago the bush had been completely cut out, hardly a stick worth mentioning being left. The regrowth timber was straight, useful stuff, but soft and immature. It was milled at a profit for light boarding and case timber.

In 1916 Mr. James Bell, a West Coast miller, wrote to me thus regarding the natural regrowth of native timber: "When I bought the land a mill had cut out all the timber that was suitable or large enough for milling, and although I had not seen the forest previous to that I could judge by the stumps what it had been like. I don't think they had cut any trees less than 2 ft. in diameter, and there were a lot of trees then left standing from 18 in. to 2 ft. When I milled it the second time I got quite a lot of trees ranging from 24 in. to 30 in. diameter. I would not expect to see such rapid growth of native timber in a dry climate, but in the moist climate on this West Coast young trees make very rapid growth."

Totara.—Mr. Percy Smith, late Surveyor-General, tells me of two cases where Totara came up thick when the forest was cleared. South of Manukau Harbour a settler cleared about 200 acres, and was going to grass or cultivate, but means failed. It came up a dense thicket of Totara. A second case known to Mr. Percy Smith was at Kamo, Whangarei—25 acres. It also came up a thick scrub of Totara.

There are many other cases of good natural regeneration of Totara. It is unnecessary to multiply examples. One may say generally that in the New Zealand forest, like the same forest elsewhere, reproduction is good where the conditions are favourable, but the conditions are so often unfavourable that less natural regeneration is generally seen than in some other forests. For a good natural regeneration the forester in his cuttings has to aim at sufficient light for the development of the young timber-trees, but not so much light as would admit a profuse growth of *bois blancs*. Where there is a dense growth of ground herbage the forester will try to get rid of that as best may be with cattle, fire, or paid labour. Failing these he will interplant.

Pines at Hanmer.—Mr. W. G. Morrison, of the Hanmer plantations, in a paper read at the Science Congress at Christchurch, February, 1919, described the natural regeneration of Insignis-pine and Cluster-pine as being already in the third generation. Insignis-pine about forty years old shows seedlings estimated at some 1,000 per acre stretching some 200 yards to windward of the parent trees. Cluster-pine shows a more abundant natural regeneration. Seedlings can be traced for a distance of two miles from the parent tree, "over country heavily grazed and infested with rabbits and hares." Larch also shows an appreciable natural regeneration, together with English Oak and Birch (*Betula alba*).

Natural Regeneration on Paper.—Those who would like to see natural regeneration on paper should turn to the photos at page 301 of vol. 1 of Schlich's Manual of Forestry, and to page 87 of the 1913 Forest Commission Report of New Zealand: the first natural regeneration produced under a forester's shelter-wood, the second by chance. The first, it is stated, shows up to 1,000 seedlings per square yard, and represents Beech in Europe. The natural regeneration in the Beech forests of New Zealand is similar (see Kirk's dictum, page 125, For. Flo.), and Beech represents the largest area, though at present the least valuable, of the forests left to the Dominion.

Literary persons and others, without an acquaintance with practical forestry, have thought to justify the present reckless destruction of demarcatable forest by saying that the natural regeneration of New Zealand forests was insufficient. It is not they who are in a position to say what natural regeneration is sufficient, or what would be the cost of improving it. But let that pass. It is evident that the weakness or strength of natural regeneration has had nothing to do with moulding the forest policy of New Zealand; because that policy is just as relentless and ruinous in the Beech forests, where natural regeneration is admittedly good, as in the Kauri and Totara forests, where it is thought by some to be insufficient.

INTERPLANTING.

STANDARD trees, over either coppice or an under-forest, are commonly dependent for their height-growth and clean timber, on the height and density of the supporting forest. Kauri and, to a less extent, the other large timber-trees of the New Zealand forest have the power, like many Eucalypts, &c., of growing with self-cleaning stems. On this point the paragraph at page 27 should be re-read. Interplanting is the form of planting that offers the best chance of success with Kauri and other native trees. Planting in the bush is not planting in the open. Mr. Matthews stated that he had tried planting in the bush and failed. He weeded and cleaned as one weeds and cleans in the open, at much cost, and with the result that the weeds only grew the faster. In planting in the bush, weeding and cleaning have to be replaced by cutting with a sickle and mulching; and where there is such a troublesome growth as fern in the north the mulching must be heavy. Against drought in South Africa I have mulched up to 1½ ft. thick. The good point about mulching is that the heavier the ground herbage and weeds, the easier it is to mulch and prevent regrowth. As mentioned later, with New Zealand labour rates the planting-disc may be more economical than mulching.

Where the foresters' regeneration cuttings, aided by the simple and inexpensive methods detailed above, do finally fail, regular planting from forest nurseries has to be resorted to. Much less frequently seeding, possibly only with a high-grade Black-wattle, may be practicable. Says Sir W. Schlich, reviewing natural regeneration in central Europe, "Natural regeneration is rarely so complete that it does not require artificial help, which can be afforded by sowing or planting, generally the latter." ("Manual," vol. 3, p. 282.) In the Kauri forests the planting would be Kauri, and, failing that, Totara, Puriri, and the introduced trees (p. 135).

In the mixed forest, where, on account of altitude or other reason, Kauri would not grow well, Totara, Rimu, Celery-top, White-pine, and perhaps also some other native trees would be planted. But what is particularly wanted outside the Kauri forest are the quick-growing self-spreading exotic trees mentioned below. In the "mixed" forest of the north interplanting will be even more necessary than in the Kauri forest, for some of the "mixed" forest is no better than Indian Teak forest, with only two or three good trees to the acre to depend on for natural regeneration. Where it will pay to work a forest intensively, interplanting offers the readiest means of improving the forest in the shortest time.

The planting would be in patches, or larger areas, just wherever it was required to supplement natural regeneration. Where the forest was "dirty," and thus difficult to plant, probably strips of selected, quick-growing and self-spreading, exotics would be put in. Details would have to be settled by the "working-plans" officer, after careful study on the spot: the "working-plan" would be at first provisional, and for limited areas, till more experience had been gained.

Mr. Jolly, the Chief Forest Officer of Queensland, a trained forester, recommends the interplanting of Australian Red Cedar, spaced about 18 ft. apart, or 140 to the acre. Sylviculturally it is like Kauri in New Zealand or Oak in Europe, growing with no very dense covert of its own above a very dense soil-covering, lower story of forest.

Two major points have to be noted about interplanting in the native "bush"—(1) economy, (2) soil-maintenance.

ECONOMY.

Interplanting would be for *standards* at first *among* and afterwards *over* an under-forest. Thus forest interplanting will be but a fraction of the cost of full planting in the open, since it is only necessary to put in a few more trees than are required to give a full stand of timber at cropping-time—say, 200 as a maximum and 100 as an average—instead of the 2,722 young trees required in ordinary planting 4 ft. by 4 ft. apart, or 1,210 for the sparse planting of quick-growing trees planted 6 ft. by 6 ft. apart.

Spacing of Trees in European Forests.—Sir W. Schlich gives the following number of trees per acre, at 100 years of age, for forest producing clean timber on land of good quality, viz.: Spruce, 220; Beech, 180; Oak, 140; Scotch-pine, 170; Silver-fir, 200: mean, 182. (Vols. 1 and 3.) Silver-fir, the shade-bearing conifer amongst European forest-trees, cut at a rotation of 100 years, yields on an average 12,530 cub. ft. q.g. per acre, of which 1,088 cub. ft. q.g. from thinnings and 11,432 cub. ft. q.g. from the final cutting. (Schlich, vol. 3, p. 372.) These figures are about 25 per cent. in excess of what I have taken (p. 83) for the normal cultivated forest of the future in New Zealand, which, turning to p. 92, it will be seen has the following data: 100 years' rotation; 100 trees per acre cubing 100 cub. ft. q.g. each; an acrim of 100 cub. ft. q.g.; and consequently a final stand of 10,000 cub. ft. q.g. Thus, 100 trees per acre to interplant would in most cases be above the average required.

Cost of Full Planting.—The cost of New Zealand full plantations of trees in the open is discussed at p. 186. It cannot, *with interest*, be taken at much less than £50 per acre, or, *without interest*, £10.

The average net cost of South African planting has been £10 per acre net, £15 gross, without interest; and the interest charge is not an easy calculation, because the plantations are accessible and thinnings saleable. These have already reduced the initial charge by one-third. Drought (and the necessity of constant cleaning to meet it), with much replanting, and always "pot-and-pan" nurseries, increase the cost of planting in South Africa; but, on the other hand, labour there is less than half as costly as in New Zealand, and, what is more important, there is such a good market for thinnings that some of the plantations have already repaid the original cost of planting, thus extinguishing the interest charge. A large proportion of sparser and cheaper (but inferior) planting would lower the cost somewhat for both countries; but for comparison with timber grown in the forest one must take the better-class close planting.

Cost of Interplanting.—With planting only where natural regeneration fails the number required to be planted now would vary from forest to forest, from acre to acre, from group to group. Let us take 100 standards to be planted now as a convenient figure for calculation.

The prime cost of young trees grown on a large scale may be taken at little over half a farthing per tree: see the schedule of rates published by Mr. R. G. Robinson in "Forest-tree Growing," p. 30. His exact figure is 0·174 of a penny—say, one-sixth of a penny. A curious confirmation of the figure half a farthing per tree comes from New South Wales. (*Vide* Forest Report for 1917–18.) In his evidence to the Forest Commission (p. 21) he quoted the equivalent of one farthing each as the cost of his trees by the time that they are in the ground. This is for good close planting spaced 4 ft. by 4 ft. apart.

In Ireland, with labour half the cost of New Zealand, the all-round cost of planting per established tree works out to ½d. (Forbes, at Avondale).

The cost of interplanting (young tree + insertion + after-care) may be averaged at 1d. per tree planted, or 8s. 4d. per 100 trees per acre. This is a Cape rate discussed in my brochure "Tree-planting for Farmers," the round figures taken there being ⅓d. nursery-cost of tree, ⅓d. planting, ⅓d. after-care; total established tree, 1d. One penny per planted tree is about the rate of the cheapest of the Australian sparse planting—Victoria, at French Island; though at the Conservators' Conference, Sydney, the Conservator of South Australia, an authority on forest plantations, gave as a figure of average cost ¾d. per planted tree. For Kauri, on account of the trouble in getting the seed, Mr. Goudie estimates 2d. per tree as a rough general average. Amongst good native timber-trees, White-pine and Totara are the two abundant seeders for easy interplanting.

As mentioned, these planted trees would grow as "standards" in (and afterwards over) the native "bush." That is why they could be planted only a few to the acre and yet give well-shaped clean timber, where a full plantation on bare ground would require from 1,210 (spacing 6 ft. by 6 ft.) to 5,000 trees per acre. Trees planted as standards in the native forest might or might not want one light cleaning. It is certain, though, that to keep them from being smothered by the ground herbage they would often require to be heavily mulched. It takes a foot or more of good dense mulch to keep down fern. "Cut and mulch" ("Australian Forestry," p. 131) is the *sine qua non* for this kind of planting. It is the want of "cut and mulch" that has spoilt some attempts already made to plant in the bush in New Zealand. Then again, some years of *nettoiements* would be necessary, as in the case of self-sown seedlings (p. 117). This mulching and *nettoiement*, with replacing failures, might run up the cost to £2 per acre, or perhaps £3 as a maximum for Kauri. This is about the cost of destroying the forest and grassing at the present time.

Interplanting costs less than Grassing.—Grassing costs rarely less than £3 an acre at present prices, and, unlike the forest planting, it has to be done everywhere; so whether the land be grassed or the natural regeneration completed by planting, the cost may be set down as on the whole less for interplanting than for grassing. This does not take account of the case of interplanting in a forest of dense undergrowth and where there was no timber-working to open up the forest. That might be more costly than grassing.

It may be noticed that the chief cost of these measures for improving the stocking would come during the early part of the first rotation of about 100 years. With improved forestry conditions, improved soil, and the study of skilled foresters on the spot, the regeneration of the forest at the second rotation from now would be considerably easier.

SOIL-MAINTENANCE.

Interplanting in the New Zealand native "bush" would have for its analogy in European forestry the "coppice-under-standard" system of regular forestry. The existing bush would keep the ground covered and without deterioration, while the planted trees would grow up as "standards" with clean straight stems. But—and this is an important point—the standards would be left to grow up close and gradually kill down the undergrowth, as is the case in a European "coppice-under-standard" forest, being converted to "high" forest.

Soil-maintenance is one of the objects ever before foresters. In soil-maintenance the native "bush" would perform the office of Beech in Europe, and, as it appeared to me, Beech in the wet Eucalypt forests of north-west Tasmania. When ninety members of the English Arboricultural Society went with him on a tour through the German forests, Sir W. Schlich summarized the function of European Beech in these memorable words:—

> Beech is the "successful foster-mother of all forest management in these latitudes." Forests, even if started pure, are under or interplanted or sown with Beech at an earlier or later period of life; for instance, Larch at fifteen to thirty years, Scotch-pine at thirty to forty years, Oak at forty to sixty years. Ash, Sycamore, and others are similarly underplanted or mixed with Beech. Even in the case of Spruce and Silver-fir forests, a moderate admixture of Beech is now insisted on, because its leaf-mould keeps the soil sweet and prevents an excessive accumulation of acids in it, as often happens where Firs are grown continually over a long period of time.

Foresters in the Black Forest aim at a 10-per-cent. admixture of Beech among the Silver-fir and Spruce. The magnificent Oaks in the Spessart Forest—"sessile" Oak, with specially valuable timber—stand in an admixture of Beech.

Apart from what is well known to foresters, here is an experimental proof of the influence of the forest-floor on the forest-tree. Fifteen years ago the Austrian Forest Department sowed experimental plots of Spruce with and without Lupins (*Lupinus perennis*). The Lupin-planted plot now shows stronger trees, towards double the size. (*Journal of Forestry*, Washington. December, 1918.) Here the Lupin probably provided nitrogen. Fungi and forest humus, it has been conclusively shown, also fix nitrogen. The work of Professor Henry, of the Nancy Forest School, on the subject may be consulted.

NEW ZEALAND AND FRANCE ALIKE IN THEIR FORESTS.

Two-thirds of the forests of France are "coppice-under-standard" forest. This is comparable with the larger part of the Kauri and "mixed" forest of New Zealand. In the Waipoua Forest the "over-forest" of Kauri and the "under-forest" of inferior timbers is everywhere more or less clearly marked. It is this two-thirds copse, with its low timber-yield but high rate of money-interest, that now makes French forests figure low in general forest statistics. It is curious to note that as soon as New Zealand forests come under scientific management there will be this close resemblance between them and the forests of France — viz., both being converted from an under-forest with "standards" to *futaie* or "high" forest. It will be a century or more before French forests get rid of their excessive coppice and before New Zealand forests get rid of their excessive undergrowth.

INTERPLANTING NOT FOR DRY CLIMATES.

It should be noted that in a drier climate than that of most parts of New Zealand interplanting would be of doubtful success. One of the first facts that came prominently to notice when European forestry found its way to South Africa was that the under-planting and interplanting of England and mid-Europe was useless in South Africa except in quite the wettest parts. The scrub and native vegetation had possession of the soil, and as soon as the droughts of summer set in the planted trees were dried out and died. In the heavy rainfalls of the Kauri and northern "mixed" forests this difficulty vanishes, while there remains the European advantages of partial shade and shelter, with the undisturbed forest soil.

Success in New Zealand.—In the *New Zealand Journal of Agriculture* of the 20th September, 1917, is an interesting account of the interplanting of Insignis-pine in Gorse and Manuka scrub by Mr. H. G. Kingsland, of Appleby, near Nelson. He says, "Trees planted in short scrub seem to come away quicker than those planted in the open. The scrub seemingly protects them and draws them up." Planting in Gorse is discussed later.

TWO PRACTICAL POINTS OF INTERPLANTING.

For success with interplanting two practical points have to be considered :—

(1.) The heavy swing-hoe.
(2.) "Cut and mulch" ("Australian Forestry," p. 231).

(1.) The heavy swing-hoe is the chief tool required for planting and seed-sowing in the forest. Wherever there is room to swing it, it is a better tool than a "grubber." When kept well sharpened it turns over the sod with little more than its own weight in the swing. The long-handled Continental shovel is common in New Zealand, but the heavy long-handled swing-hoe seems as rare in New Zealand as in England. Englishmen are not adepts in using it. A few years ago, when the Norfolk (England) farmers took to planting Sugar-beet, they had to import Dutch labourers to hoe the beet. Yet the work is not heavy for those used to the tool. It is favourite women's work in countries where the women lead more outdoor lives and are stronger and healthier than in English communities. I have seen a Dutchman in South Africa go through a stout 3 in. sapling with a heavy swing-hoe nearly as easily as an axeman with an axe.

Professor Recknagel, a well-known American forester, describes the use of the swing-hoe in artificial regeneration, Austria. It is almost the only tool for cutting through the debris and matted roots of the forest-floor.

(2.) "Cut and mulch" has been mentioned above (p. 59). It is fully described in "Australian Forestry" at page 231.

DISC WEED-STOPPER.

With labour as high as it is in New Zealand the mechanical disc weed-stopper could probably be used economically in place of mulching.

The disc is from 9 in. to 1½ ft. in diameter, with a hole in the middle 1½ in. or 2 in. in diameter, and a slit leading up to it ¼ in. or ¾ in. wide, so that the disc can be easily slipped on to the planted tree with a little bending of the disc. The disc is preferably made of thin sheet zinc. It stops all weed-growth near the planted tree, and keeps the ground around it as clean as in a garden.

It is stated that there is an overproduction of zinc in America, and various new uses for the metal are suggested. A disc weed-stopper in countries where labour is as costly as in New Zealand seems one new use for sheet zinc.

The placing or the moving of the disc is light labour, whereas "cut and mulch" is heavy work that may have to be repeated more than once with trees that grow at first slowly.

The disc work could be done by partially disabled returned soldiers, or by rangers in the course of their rounds. The disc is not removed till the planted tree has established its own "covert"—viz., in two, three, or more years. The planting-disc gives almost the only chance for successful *in situ* seed-sowing in bush like that of New Zealand I have used disc weed-stoppers in India, but there is little scope for labour-saving devices in a country where labour is so cheap that railway embankments are made by a procession of women and children carrying baskets of earth on their heads!

Besides economy in the number of trees required, interplanting has other advantages in a New Zealand forest, viz.,—

(1.) Thinnings, for which there is often no sale, would be saved. The first thinning is generally unremunerative in every country. It averages about £1 per acre in young pine forests in South Africa, with labour one-third the price of that in New Zealand, so that here is all the cost of the interplanting saved in this first item.

(2.) Cleaning and weeding may be less and be more easily replaced by mulching.

(3.) Pitting in the soft and open forest soil is never wanted.

(4.) Rabbit fencing is very rarely necessary in the native forest.

(5.) Fire-protection is easier.

(6.) As against bad sparse planting, and even with some trees close-planted, the cost of side pruning would be saved or greatly reduced.

(7.) Trees planted in the "bush" get shelter from wind, which is often so serious a drawback in New Zealand, and that modicum of shade in youth which even many light-demanding species love—the Tulip tree for instance.

(8.) Planting in the "bush" means necessarily a certain gain in the quality of the soil, since the forest soil is the net result of centuries of soil-improvement.

(9.) Lastly, there is the great prospective gain of the valuable foreign trees spreading naturally in the forest, as does so much introduced vegetation in the open.

Against the above nine items has to be set some lopping, ring-barking, or felling required to prevent the interplanted standard trees becoming dominated; but this would rarely be a serious item, and is comparatively light-labour work which many discharged soldiers would find congenial and others would take on in the intervals of farm-work.

EXOTIC TREES FOR NORTHERN FORESTS.

I HAVE been asked to mention what trees are suitable for planting at Waipoua and in Kauri and northern forests. The following short list* is therefore brought on here, though I feel it is not of great use, because little work can be done in forestry without a technically trained staff, and such a staff would soon be in the best position to state what trees were most suitable for this purpose. Nevertheless this list may be of some use, because it is the outcome of my practical experience of tree-planting in South Africa in the latitude and much the same climate as the northern forests of New Zealand. I once entertained a New-Zealander in the Pere bush, near King William's Town, South Africa. His one theme in our daily walks through the bush was that he was back in New Zealand. This was a climate resembling the upper Waipoua or Tutamoe forests—a climate up to 100 in. rainfall, with light frosts and rare slight falls of snow in winter.

With the exception of Californian Redwood, Australian Cedar, Blackwood, the Tulip tree, and American Hickories, I could recommend the planting of few other exotic trees to compete with Kauri. In the under-forest various trees might be tried, but only by competent foresters with all necessary precautions. The economy of nature, and the balance of vegetation, in so valuable an entity as a Kauri forest, is not to be lightly interfered with.

In Totara and in "mixed" forest, where it was known Kauri would not thrive, or for planting on much of the poor northern land, *especially under arrangement with "gum-diggers" to turn over the soil systematically*, the following trees, amongst others, deserve notice, viz. :—

Insignis-pine at Waipoua shows a fair growth on poor soil at the Marlborough Settlement; almost a phenomenal growth on the rich soil of the Waimamaku Valley. The height-growth, judging from Mr. Heath's trees at Marlborough, is 3 ft. to 4 ft. per year. A tree near the post-office at Waimamaku was 3 ft. in diameter by 90 ft. high at twenty-five years. At Helensville, Whangarei, and Dargaville it seems to grow quite as vigorously as elsewhere in New Zealand.

Other desirable trees are Cluster-pine, Loblolly-pine (*Pinus taeda*), *Pinus thunbergii* and *Pinus densiflora* of Japan, the straight-growing form of the common Macrocarpa Cypress, Busaco Cedar (*Cupressus lusitanica*); amongst Gums—Blackbutt (*E. pilularis*), the Ironbarks (*Eucalyptus paniculata* and *siderophloia*), Tallow-wood (*E. microcorys*), Forest Mahogany (*Eucalyptus resinifera*), and *E. saligna*. A good strain of Black-wattle is particularly wanted. It is very important that no more worthless Wattles be introduced, as most unfortunately has been the case in New Zealand with the absence of forestry in the past.

The Hon. E. Mitchelson enumerates the following ten native trees as worthy of cultivation north of Auckland: Kauri, White-pine, Totara, Rimu, Puriri, Tanekaha, Towai, Mangeao, Kowhai, and Manoao.

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* A more extended list appears in "Forests of the South and Mid New Zealand." Of the two common timber-trees planted throughout New Zealand, Insignis-pine appears in both lists, and Macrocarpa Cypress in the southern list only.

GUMS FOR THE SANDY PENINSULA OF THE EXTREME NORTH.

For the sandy peninsula of the extreme north of New Zealand, though the choice Gums growing in the same latitude in eastern Australia should be well tried, the following from the sandy coast lands of Westralia may give the best results. The climate between Cape Leeuwin and Albany resembles that of the extreme north of New Zealand. It is equable and wet, without the hot winds of eastern Australia.

TUART (*Eucalyptus gomphocephala*) deserves perhaps first mention here. Among Eucalypts it is fairly fast-growing. Its timber is fairly durable in the ground (not, of course, like Jarrah), and very strong. See the very favourable report of a railwayman at p. 37 of "West Australian Timber Tests" by Julius (Forest Department, Perth, 1917). So strong and tough is the timber that it is a favourite wood for railway-truck frames in Westralia, in spite of its excessive weight of 68 lb. per cubic foot air dry (12 per cent. of moisture). This weight is 4 lb. per cubic foot more than Ironbark. Such a weight, though it detracts from the usefulness of a timber, gives the firewood a heating-power equal to many descriptions of coal. So valuable is the timber that in the days of rude Government methods and no Forest Department its exportation from Westralia was banned.

The Tuart forests are small, nearly all private, and confined to a narrow coastal belt 150 miles long. Seed for New Zealand should be obtained from the extreme southern end of this belt, near Busselton. This valuable tree flourishes on a limestone formation and on drift sand. In South Africa it has been planted with conspicuous success in drift sands containing too much lime for the ordinary Maritime-pine (*Pinus pinaster*). This is on the sands of the Cape Flats skirting Cape Town in latitude 34°. In the extreme north of New Zealand, in the same latitude and climate, south of Cape Maria van Diemen, it should do equally well, provided there is enough lime in the soil—which probably there is, for most drift sands, in part at least, contain shell and marine deposits rich in lime. Tuart should flourish, and be perhaps the most valuable production of the soil, along the whole of the long narrow peninsula, forty miles long, stretching south to Rangaunu Bay. Indeed, on account of its particularly valuable timber, Tuart may be worth planting as far south as Waipoua, or even farther south along the coast sands past the Kaipara Inlet.

I may mention that the Conservator of Forests in Murcia, Spain, took me in 1914 to see his sand-dune planting, and there among the best of his trees was Tuart growing in white drift sea-sand just as it does near Cape Town. Murcia is in latitude 38° and the warmest part of Europe—the only part where the common Date tree ripens fruit on a commercial scale.

If crude methods and backward forestry have lost to New Zealand the demarcatable part of the noble Forty-mile Bush, north of Masterton, the Tuart Gum may give New Zealand another "Forty-mile Bush" on these sandhill wastes of the extreme north!

Tuart will withstand fairly strong sea-wind, but I think should be first tested on the eastern coast. In sand-fixation Tuart is complementary to Maritime-pine, flourishing in sands where, as mentioned, lime in the soil kills or stunts Maritime-pine (*P. pinaster*).

Under cultivation Tuart grows well in South Africa in any ordinary soil, in some soils containing little or no lime, so that it probably tolerates lime rather than requires it; but the South African trees are not yet old enough to prove this.

Recognition.—The foliage has a fresh green colour. I have heard Westralians call Tuart their handsomest Gum. But it is easiest recognized by its bud, which has a swollen top when young and green, with the cap on. The botanical name means "swollen head." The mature cones such as one picks up on scratching about under the tree are shaped just like a church-bell, with not very prominent teeth (valves) at the mouth.

KARRI (*Eucalyptus diversicolor*) is a more southern, more cold-country tree, than Tuart. It is the best-known Gum of Western Australia after Jarrah. It is quick-growing, has a strong natural reproduction, and great strength for structural purposes, but is not durable in the ground. It is a tree of the first economic importance in the forests of Western Australia, where it forms both pure and mixed forest in dense stands of rapid growth. It has been planted with complete success in South Africa, but not to a great extent, on account of the timber's want of durability, used as a sleeper. It likes good soil, but grows fairly on poor sandy soil.

JARRAH (*Euc. marginata*) would also do well here. I have seen it growing wild in the poorest sandy soil in the same latitude as the extreme north of New Zealand. Whether on poor soil or good soil it grows too slowly for planting purposes; but it is well worth introducing to constituted forest lands, as it has a good natural regeneration, and is peerless among Eucalypt timbers.

YATE (*Eucalyptus cornuta*) should also be tried on the sandy peninsula of northern New Zealand. It is heavier and stronger than even Tuart, its air-dry weight being 71 lb. per cubic foot. According to Julius's timber tests it is the strongest of all Eucalypt timbers—probably of all timbers. I have grown it successfully in South Africa (at Concordia) in exactly the poor sandy soil of this sandy northern peninsula of New Zealand. It grows quickly and in good form. It is fully described in my "Australian Forestry," p. 235. On an average Mr. Julius's tests give Yate a tensile strength almost exactly half that of wrought iron, *bulk for bulk*, so that Yate, *weight for weight*, has, say, three times the tensile strength of wrought iron and nearly three times the transverse strength. In New Zealand railway-carriage building, where weight means so much, the use for such a timber as Yate is obvious. Consider only the clumsy heavy iron gates and railings on the outside of New Zealand railway-carriages, though it is not necessary to find such a wood as Yate to replace them. In South Africa on the same class of car Teak is used.

BUSHY YATE (*Euc. lehmanni*, or *E. cornuta* var. *symphyocarpa* of Mueller).—This is the wind-resistant small tree planted so extensively at Cape Town in situations where no other tree would flourish. I have described elsewhere the value of this tree as a breakwind at Cape Town. It is too small a tree to produce sawing-timber, but it makes first-rate firewood that breaks up easily under the axe. Its cones occur in huge woody knobs the size of a child's head. One of these alone will boil the pot. It has run wild on the very poor sandy soil of the Cape Flats, near Cape Town.

Maiden describes it (Crit. Rev. of Eucalypts, vol. 4. p. 113) as *E. lehmanni*. Bentham kept it as a variety, but Naudin said, "*E. lehmanni* is certainly one of the most distinct species of the whole genus." Naudin is right as far as I have seen the two, but Maiden adds, "It may be that *E. lehmanni* and *E. cornuta* pass into each other as we go east." Even admitting this, the type of the two trees, as I have seen them in Western Australia and under cultivation, are (as Naudin says) as distinct as any two species in the genus.

I have not grown the following two species, but they may be worth trial.

RED TINGLE-TINGLE (*Euc. jacksonii*).—Red Tingle grows on the Franklin River about forty miles to the westward of Albany, and is credited to grow up to 350 ft. in height. It is confined to a small area about six miles deep and fifteen miles long, alongside the river. Says Conservator Lane-Poole: "I have not yet seen the country, but the timber is excellent, and, weight for weight, comes next to Karri. It is stronger than Karri in transverse strength and cross-compression, while its tensile strength is 15,700, as compared with 18,750 for Karri."

Another suitable tree, growing in much the same locality, is the so-called Yellow Tingle-tingle (*Euc. guilfoylii*). This is not a large timber, but is said to be durable in the ground. It may be quick-growing.

The Kauri-gum Commission of 1914, p. 21, estimated 100,000 acres of Crown land and 200,000 acres of private land were affected by the sand-drift of the extreme north of New Zealand.

THREE SPECIAL PINES.

Short-leaf Pine.—As a tree for the "mixed" forest the "Short-leaf" Pitch-pine (*Pinus echinata*) seems particularly useful. It grows in the Gulf States, U.S.A., in a very wet climate. It is an important timber-tree, covering a wider area than any other pine in the United States, the young trees coming up like grass and shooting again when burnt. It does not grow as fast as Kauri, so that there seems no danger in letting it into a Kauri forest; but it would be advisable to try it first in "mixed" forest. The following extract shows the typical tree aimed at by the American forest management:—

> On the national forests of Arkansas the Federal Government in its management of Short-leaf Pine aims to produce the sort of material most needed by the people, which is mostly medium-sized saw timber. A rotation of about 100 years in fully-stocked pure stands affords the largest yearly yield. The average tree at this age, grown under forest conditions, is 74 ft. in total height by 16·6 in. in diameter, and contains not less than 270 board feet of merchantable timber.

This is a very much slower growth than Kauri under the same circumstances (p. 14).

Cuban-pine versus *Insignis.*—The Cuban-pine from the northern part of its habitat in south Carolina is well worth trial in northern New Zealand. *It is a pushing, fast-growing, fire-resistant, valuable timber-tree; in the forests of the Gulf States, U.S.A., producing resin at forty years, and fit to cut for timber at fifty. It is one of the best of the Pitch-pines, and gives a first-class house, sleeper, and railway wood.* Both the climate and soil of this tree are those of northern New Zealand. If the tree should take kindly to a new home in New Zealand, reproduce itself abundantly, and produce first-class Pitch-pine timber in fifty years, it is easy to see how such a tree would enhance the value of the northern forests. That it will do this is not merely a probability, but almost a certainty. Says W. R. Mattoon, of the Research Branch, U.S.A. Forest Service, "It is very doubtful if any other North American conifer combines silvicultural and economic qualities of an equal value."

He could hardly say more; and this strong praise is fully endorsed by various other competent observers. Professor Sargent, in his Silva of North America, describes it thus:—

> The most beautiful of the pines of the southern States; the broad, compact, shapely dark heads of the Slash-pine, raised on massive trunks, stand out boldly among the more open-headed and less symmetrical Long-leaved (*P. australis*) and Loblolly Pines (*P. taeda*), which it seems destined gradually to replace and to become a chief factor in the restoration of the southern pineries. For its seedlings, produced in great numbers every year, are able to thrive without direct sunlight, and, overcoming the more slowly growing seedlings of the other species, sooner attain sufficient size to resist the fires which endanger all young plants in the Maritime-pine belt of the south.

I have seen Cuban-pine nowhere in New Zealand. It seems one of the good things to come to the Dominion with good forestry. Being naturally a summer-rainfall pine, it should not be liable to disease in New Zealand like Insignis, Cluster, and other dry-summer pines.

Compared to the growth of Insignis-pine in New Zealand, Cuban-pine is decidedly slower on good soil, but it seems as fast on bad soil, which is more important. In America, with land at £1 an acre, Cuban-pine is calculated to return 8 per cent. net, after deducting taxes and cost of management. The timber-yield figure (acrim) seems to average about 145 c. ft. in quite young stands. (For. Quart. for Dec., 1916.) These are extraordinary figures, especially if one considers the high taxation put on forest property in America. The initial difficulty with Cuban-pine is seed. I tried in vain to obtain it for many years in succession. The American Forest Service is now better organized, and could probably supply New Zealand at this time. Cuban-pine has had various names. The old botanical name was *Pinus cubensis;* the names just now in fashion are *P. heterophylla* and "Slash"-pine.

Canary-pine (Pinus canariensis).—In this connection I should mention the Canary-pine, though it would, I fear, be rather too wet for it, even on the driest coast lands of the north. But Mr. Phillips Turner tells me that he has seen trees in the north growing as fast as Insignis-pine. The description of it in "Australian Forestry" may be referred to.

It is so valuable a tree that in South Africa it has been planted more abundantly than any other pine except Cluster-pine, and it is intended, in all the thinnings, to take out Cluster-pine and leave Canary-pine to form the permanent forest. There is probably more of this pine now in South Africa than in its restricted home in the Northern Hemisphere.

Its valuable qualities are that the heartwood is about as heavy and strong as Jarrah, and seemingly twice as durable. It thus furnishes a first-rate sleeper. The Spaniards call the heartwood "Pino Tea." There is quite a literature on its durable qualities. The sapwood is no better or worse than ordinary pine-wood. The tree grows fast, and if by chance it gets burnt will shoot again. In New Zealand it may be seen growing as far south as Christchurch. It does well in the dry climate of Hobart, but is seen best in Australasia as an ornamental tree in the Adelaide parks. It is the most remarkable tree of South Australia.

Araucaria brasiliensis.—If not the most valuable tree in South America, it appears to be the tree forming the most valuable forests. In Brazil, in wet mountainous climates similar to the mountain forest lands of northern New Zealand, the Brazilian Araucaria forms *pure forests* of large extent and great value. In these forests, recently opened up by the making of the Parana Railway, American sawmills and lumbermen are now at work. That this tree can form pure forest in that latitude shows its self-spreading power and strength against other vegetation. It promises to be a valuable addition to the forests of northern New Zealand. As a planted tree it grows well at Lower Hutt and as far south as Canterbury. There is a fine large tree in Mason's Gardens, in the Hutt Valley.

It grows well in southern France and northern Italy and Portugal, but as a forest-tree should be more at home in the wetter climate of New Zealand. In South Africa it stands the severe frosts of Johannesburg (6,000 ft. elevation), and grows there at the rate of 2 ft. or 3 ft. per year.

The timber is good: it is claimed to be the best of all the Araucarias, as Kauri is the best of all trees of the genus *Agathis*. These are closely allied genera. It would be a striking sight to see the best trees in each of these two genera of fine timber-trees growing side by side in the future Kauri forests of New Zealand!

The nuts are borne abundantly in huge cones the size of a child's head. Not being so large as the nuts of the Bunya-pine they are better adapted to distribution by rats, mice, and birds; but they are large enough, when produced abundantly in the forest, to help the languishing pig industry of New Zealand.

It should be noted that the Araucarias, though producing timber equal to the best and straightest pine and fir timbers, are freer from fungoid disease. On the eastern semi-tropical coast of Africa, where in the heat and summer rains most pines fail, Araucarias grow without blemish.

Araucaria bidwilli (Bunya-bunya), of mountains of south Queensland, is possibly not hardy enough as a forest-tree even in the warmest Kauri forests; but as a planted tree it grows alongside the Rimu in South Africa; and at 2,000 ft. elevation in Natal grows as strongly and produces pig-feed as abundantly as the English Oak at Cape Town. The seeds are one of the largest and most nutritious of tree-nuts. Tribes of savages fattened on them in the old days in Australia.

This valuable tree is being propagated by the Queensland Forest Department, as much as 1½ tons of seed being reported sown during the year 1917.

Araucaria excelsa (Norfolk Island Pine).—As a planted tree this is perfectly hardy everywhere in the Kauri country, growing rapidly to a lofty tree and showing yearly shoots up to 6 ft. in length. In the Canary Islands I have seen yearly shoots up to 9 ft. in length. There is good evidence that (unlike the "Monkey-puzzle" tree) these shoots are yearly. Norfolk Island Pine is well known for its ability to stand sea-wind, and is a favourite ornamental tree in northern New Zealand, Australia, and South Africa. It is a good timber-tree, but is subject to black smut and scale (*Eriococcus araucariæ*) both in South Africa and New Zealand. Its usefulness as a forest-tree has not yet been tested.

Tulip Tree (Liriodendron tulipifera).—This is a very valuable quick-growing softwood that may be of first-rate importance in the Kauri forests, replacing useless undergrowth; but as a young tree in the Auckland Domain I could find no signs of natural regeneration. It is easily recognized from its large tulip-like flowers and its dense foliage, with broad leaves like a Plane tree, the top of the leaf flat as if snipped off with a pair of scissors. As an ornamental tree it is almost without rival. It is free from the diseases troubling the Plane tree, and nearly all other diseases. There is a promising avenue in the Government plantation near Rotorua. It is described later, as its use extends right through New Zealand from north to south. The largest trees in New Zealand are at Lower Hutt, and there it seems at its best.

Cypress-pine (*Callitris macleayana*) is well worth introducing to the Kauri forests. There is a remarkable tree at Gosford, N.S.W., which at ten years is 10 in. diameter by 35 ft. high. It made a 5 ft. shoot last year. Most of the Callitrisses have a good natural reproduction, and belong to the best class of timbers—durable softwoods; but many of them are slow-growing trees of dry climates.

OAKS.

There should be some Oaks, if only to help the pig industry referred to above. A little Oak planting I know from experience will go a long way in this. *Quercus michauxii*, a fine tree with large *sweet* acorns and good timber, is probably the best Oak to plant in the north, but it is difficult to get genuine seed. There are some other Oaks of the Gulf States of the United States of America nearly as good. *Quercus lusitanica*, the best Oak of Portugal, is already growing well in northern New Zealand. There are particularly fine specimens of the English Oak (*Quercus pedunculata*) here and there on the old mission stations, but I doubt if this is hardy enough for growth as a forest-tree generally. It has been tried without success by Mr. Matthews. It remains for trial by foresters.

The cold-country Oaks will be referred to later.

HICKORY.

The Hickories are decidedly slower in growth than the Kauri, and so can be planted with it without danger. Of these, Shagbark (*Hicoria ovata*) is the best, then *H. lacinosa*, *H. alba*, and *H. glabra*. Though all the Hickories are somewhat slow-growing, their sapwood is more valuable than their heartwood, so that they can be cut young to save the planting interest charge. There are some good Hickory trees at Mason's Gardens, Lower Hutt. A small supply of seed (nuts) could be got from these; they bear well. Seed from the Gulf States, United States of America, should be specially procured for planting in northern New Zealand: care in cool storage is desirable to get it through the tropics in good condition. Hickory may be a very valuable addition to the tree flora of Waipoua and other forests. Of the five valuable kinds in the United States of America, it should not be difficult to find one that will be hardy and push its way with natural regeneration. Some of the best Hickory in the southern United States of America is found growing on clay land, and a temperature to closely match the Waipoua Forest. Tool-handles are imported on a large scale to New Zealand.

ASH.

Ash may be more useful generally than Hickory. I shall refer to it in connection with the southern forests.

RED CEDAR AND BLACKWOOD.

The two Australian rivals of Kauri—Red Cedar and Blackwood—are both worthy of extended trial in northern forests. Blackwood (*Acacia melanoxylon*), the valuable softwood of Australia, is at home right through the Northern Island. It is important to plant only a good strain and to make some tests of its early growth against Kauri. Blackwood from northern Tasmania seems suitable.

Australian Red Cedar (*Cedrela australis*) might be a very valuable tree in the lower parts of the Kauri forests. It grows in Australia as far south as latitude 36—the latitude of Dargaville in New Zealand. It matures in eighty to a hundred years, thus rather earlier than Kauri. In its usefulness it rivals Kauri, and grows up to diameters of 13 ft. or perhaps more.

Red Cedar is the Kauri among Australian timbers—the best timber of Australia. Its value and huge size are often quoted in Australian literature. Large trees worth £800 apiece (in the log at ship's side) are mentioned. But actually the biggest Australian Red Cedars are small timber-trees compared to New Zealand Kauri trees. Maiden quotes maximum dimensions of Red Cedar as 10 ft diameter and 200 ft. high, with exceptional trees somewhat exceeding these dimensions (p. 46). One of these exceptionally large trees was "calculated to yield 30,000 sup. ft. of saleable timber" (Forestry Handbook No. 2, 1917). This is about one-tenth the size of the record Kauri trees.

Red Cedar of Australia resembles Kauri in that it is more the huge size of certain trees than their abundance that is remarkable. Thus the Bellinger River forest, one of the best Cedar areas, is stated to have had only 30 million sup. ft. of Cedar sixty years ago, but one tree is recorded to have yielded Cedar worth £700. As has been seen, a giant Kauri, at present prices, might easily yield double this figure.

Red Cedar is already growing well in the Hokianga district. I have heard of a missionary-planted tree with nearly double the diameter-growth of Kauri. Mr. Black, of the "Promenade," Palmerston North, describes its natural regeneration at Cairns (North Queensland) as profuse. Australian Red Cedar should be well tried in the most northerly of the Kauri forests, taking care that its particular pest, a twig-borer, is kept out. It may grow profitably as far south as Kauri grows naturally. It compares thus with Kauri :—

Value.—It has much the same value as Kauri on the Australian market.

Very Rapid Growth.—It grows faster than Kauri; in Queensland four or five times as much in height-growth, and three or four times as fast in diameter-growth—the average is nearly ⅓ in. per year till over 200 years old—from stump-ring readings. It would not grow as fast as that at Waipoua.

One Tree per Acre.—Like Kauri, "Cedar occurs in scattered belts. It nowhere forms pure forests, for, being unable to preserve a dense forest canopy, it is always associated with other species over a dense underwood. Land with an average of one mature Cedar per acre would be good Cedar country" (Conservator Jolly, Queensland).

Bole.—Though buttressed at the base, it forms a good cylindrical shaft of timber, its maximum height of bole rather less than Kauri, and its maximum diameter about half that of Kauri.

Propagation.—Red Cedar is easily reproduced from either seed, cuttings, or coppice shoots. Mr. Jolly recommends interplanting in the bush at not less than 18 ft. by 18 ft., or about 140 to the acre. This is significant (see page 129, "Interplanting").

A Bad Pest.—The Cedar twig-borer (the grub of the moth *Hysiphyla robusta*) is a very serious pest in Australia. It has at least two broods a year, and bores into the leading and side shoots, killing them back repeatedly. Cedar plantations on a large scale are considered inadvisable for this reason. Heart-rot is common even in well-developed trees. (Forest Bulletin No. 3 of Queensland, October, 1917.)

Seed is good, but does not keep well. After long delays in getting good seed I succeeded at last in planting Australian Red Cedar in the South African forest resembling the New Zealand "mixed bush." It is growing very well, and promises to be specially valuable introduced to a country free of its pest.

OTHER CEDARS.

A closely allied species is *Cedrela odorata:* on equatorial highlands (Nairobi) in an arboretum group it averaged 25 ft. high in three years. This is one of the best-known Cedars of commerce. *Cedrela serrata* of the Himalayas might flourish over a larger part of New Zealand, and *C. velloziana*, a first-rate timber-tree of Brazil, in the northern Kauri forests.

EXOTICS FOR LOW, WARM CLIMATES.

The belt of "Brush" forest in New South Wales, which in climate and vegetation approximates to northern New Zealand, extends south as far as latitude 33½°. Waipoua is in latitude 35½°, but the "Brush" forest spreads up to an altitude which more than compensates for the slight difference of latitude. The "Brush" forest of New South Wales is dense evergreen forest of the same general character as Kauri forest, the rainfall being similar. The valuable timbers of the New South Wales "Brush" forest for trial in the Kauri forests are: Red Cedar as above, Silky Oaks (*Grevillea robusta* and *Orites excelsa*), White-beech or Teak (*Gmelina leichardtii*), and a valuable Rosewood (*Dysoxylon lessertianum*). Of these only the Red Cedar and Silky Oak have a value comparable to Kauri; but there are parts of the Waipoua Forest where Kauri does not seem to thrive, and where these "Brush" timbers of New South Wales might do so. They should be tried there. None of them are trees likely to spread so as to get out of control or to compete with Kauri except Red Cedar, and that is as valuable as Kauri.

Silky Oak.—Silky Oak (*Grevillea robusta*) is a quite valuable tree, both sylviculturally and for its timber. It has the covert and soil-improving qualities of Beech in Europe. It is an extraordinarily hardy tree, growing fairly far outside its natural habitat—Hobart and Melbourne, for instance. As a beautiful tree it may fairly be said that only the *Metrosideros* trees of New Zealand (Ratas and Christmas tree) compare with the Australian *Grevillea robusta*. It has been nearly all destroyed in New South Wales, but now, with the turn of the tide in forestry, will doubtless be brought back again. It grows with rapidity and great vigour in Auckland. Its scarceness there is ascribed to a transplanting difficulty. This vanishes in a pot-and-pan nursery, but I am inclined to think there is something more against it in Auckland—perhaps wind. On the equatorial highlands of South Africa (Nairobi, 6,000 ft) it grew 20 ft. in four years. In Kauri forest it would grow faster at first than Kauri, but might prove of the utmost service silviculturally for under-planting Kauri. For ornamental panelling in railway-carriage work the Railway Department might prefer it to Kauri. Though it does not take varnish so well as Kauri, it seasons better, and weighs less. (The better type of railway-carriage coming may be free of varnish.) Cut on the quarter, it is more ornamental. *Orites excelsa*, the other Silky Oak of Australia, should be planted with *Grevillea robusta*. It is even lighter in weight and equally ornamental.

"EXTRA-TROPICAL": THE TERM DEFINED.

"Extra-tropical" (sometimes shortened to "ex-tropic") is here used, as employed in South Africa and Australia, to designate the parts of those continents lying outside the tropics. In other countries it is applied to the zone between the tropics and the warm temperate: in Europe, the Mediterranean; in America, California and the southern States. In New Zealand the Auckland District and the coastal country as far as both sides of Cook Strait may be considered the extra-tropics, but there is no marked line of division. Kauri, Puriri, Celery-top, and other extra-tropical species disappear from the forest, but its character remains the same. Extra-tropical forests are generally sufficiently different in character from the forests on either the warm or the cold sides of them; but that, owing to its long isolation and abundant moisture nearly everywhere, is not the case in New Zealand, where the "mixed forest," a typical ex-tropic type of forest, extends with little change to the extreme south.

"Sub-tropical" is a loose and misleading term, there being generally a very marked difference between the climate and vegetation of the tropics and the extra-tropics, especially in the forests.

The extra-tropics, outside the dry and desert country, are characterized by a dryish atmosphere, bright sunshine (here is the maximum of summer insolation), and heavy rain at intervals. When this rain is enough to provide abundant subsoil moisture the conditions required for the most vigorous tree-growth are attained. Thus, it is in the extra-tropics that are found the world's largest trees—the giant Sequoias of California, the giant Eucalypts of Australia, the world's biggest timber-tree (the Kauri, of New Zealand), the big Yellow-wood of South Africa, and the long list of noble trees found in the Caucasus, the Himalayas, and Japan. Few tropical trees come near these in size, and fewer still among the trees of temperate or cold climates.

New Zealand may have restricted mineral wealth and grass that is difficult to maintain, but it is in the right place on the world's surface for the best tree-wealth. Of this tree-wealth the best now is in the northern or extra-tropical part—the most valuable species and the largest trees.

FIRE.

Fire Danger in a Kauri Forest.

The general aspect of fire-protection in an organized forest is discussed in my "Australian Forestry" (Perth, 1916); and in a Kauri forest at pages 30–32 of "Waipoua Kauri Forest." It will be sufficient to remark here that though there is little danger of fire in the Kauri forest in its natural state and in ordinary wet years, there is real danger in exceptionally dry years, or when the forest is worked.

Said Mr. E. Harding to the Forest Commission of 1913 (p. 43):—

> The rainfall [at Waipoua] is very high, but in such districts there occasionally comes a period of drought, when fires will occur and spread. There is no class of country more inflammable than a Kauri bush. Every credit must be given to those responsible for protecting this forest [Waipoua] in the past, but the time will come when a huge fire will occur with the result that, as at Puhipuhi, many thousand feet of most valuable timber will be lost to the Dominion.

We may distinguish three sorts of fires in a Kauri forest—(1) Crown fires, (2) ground fires, (3) working refuse-fires. The last is the common fire in Kauri forest. Without it the fire danger is small. The Waipoua Forest was overrun with "gum-diggers" for twenty-five years, and no fire worth mentioning occurred. Crown fires are described to me as being more common than I should have supposed. The ordinary forest fire in India and in South Africa is the ground fire.

The Kauri tree, say all the bushmen and Government forest men, is easily destroyed by fire. It is said popularly that the smoke of a fire will kill it. It is certain that a crown fire will easily kill it, and that a ground fire getting into the heap of refuse bark and resin-droppings at the base ("bukau") will burn there for long—even, it is said, through the dripping-wet winter—and naturally kill the Kauri tree. The detection and extinction of these smouldering fires is, of course, one of the essentials of a more completely organized Kauri protection.

Every part of a Kauri tree (perhaps as much as with pines of the Pitch-pine class) is full of resin, and but for the wet climate of the Kauri forests as much organization would be required to protect them as is the case with the pine forests of the Mediterranean. Northern bushmen have been so accustomed to seeing the Kauri forest burnt when they work it that it may be advisable, when working the Kauri forests by Government, that southern bushmen should be employed, wholly or in part. I have heard of a case where a Kauri miller took precautions and, even with northern bushmen, nearly succeeded in quite excluding fire. Smoking was prohibited, and two men promptly dismissed for breaking the rule.

Public sentiment in the matter of forest fires in New Zealand is weak. Thirty years ago, in South Africa, Magistrates would rarely inflict more than nominal penalties, the feeling being that after all a man had to live, and to burn the forest to produce crops or grazing was a venial sin. Then came a little deeper insight into the matter, the sentiment that man does not live by bread alone, but that he wants housing and firing, and that he must look to the forest for this. I understand that in New Zealand up till quite recently it was common for a Magistrate to inflict a nominal penalty of 5s. in fire cases. Considering the difficulty of proving forest fires, such penalties are nothing more than an encouragement to set fire again!

I have come to the conclusion—and I have seen nearly every class of forest fire—that only reasonable precautions are necessary to preserve the Kauri forest from fire, whether as virgin forest or whether in the worked condition; whether the "over-wood" be pure Kauri or mixed Kauri forest.

Mr. Atkinson protected his fine little Kauri forest (300 acres) near Auckland City for thirty years merely by putting up notice-boards and keeping an eye on it. This forest, now Atkinson Park, was cut down sixty years ago and all burnt. The fine stretch of forest we see to-day is entirely natural regrowth. The natural reproduction one sees is a perfect object-lesson, especially as the original cutting was not done so as to favour natural regeneration. An application of some of the methods described at p. 116, or a little inexpensive interplanting, would have produced a completely stocked normal forest of Kauri.

Burnt Kauri Forest and Swamp "Gum."—Judging from present appearances and from what I have heard of fires in the past there seems little doubt that the coast side of the Waipoua Forest has been destroyed by fire—first the fires of the Maoris, latterly the Maoris and "gum-diggers" combined. The shrinkage of the Kauri area from the area of the present gumfields to the small area of the present Kauri forest has been caused solely by fire. Of this, to a forester who has lived in South Africa and seen the action of fire on the similar forest of that country, there can be no doubt. It is not necessary to invoke changes of level or changes of climate to account for the presence of Kauri fossil "gum" in swamps. The Kauri trees grew there once and were destroyed by fire. That is the natural explanation of Kauri "gum" now found in swamps. Both Kauri "gum" and Kauri timber in all stages of preservation are found in swamps. The rank vegetation of swamp land burns fiercely in exceptionally dry years, while the gum-droppings and crown pieces of "gum" sunk in the lower wetter parts would be protected, or only scorched by fire. That is the appearance of the swamp "gum" one sees to-day. It has been stated that Kauri does not flourish on swampy land, and that may be true for swampy land near the coast. Kauri certainly grows freely on swampy high land in the Waipoua Forest, and I have seen large Kauri logs and "gum-spearing" in swamps elsewhere.

Fire and Timber-working.—It is not only Kauri timber that is so valuable, but the shapeliness of the Kauri log. Soundness and absence of taper are the characteristics of Kauri logs. Yet this very shapeliness of Kauri has helped to destroy the Kauri forests. The great logs are cut up into sections like tubular boilers; and these, *when the forest has been burnt*, are rolled down the slopes, or jacked and levered along the flat to the nearest stream, to await a flood or the breaching of an artificial dam. Kauri-log working and the burnt forest is well pictured in the Lands Department, 1907, "Report on the Timber Industry of New Zealand."

Usually one fire will not clear the bush. Then repeated fires are set, by which time the Kauri sapwood is usually riddled by borer; but the heartwood remains sound for an indefinite period, and is always worth rolling out as long as the forest is kept burnt and the way clear.

BURNING OF A KAURI FOREST: A WORD-PICTURE.

I quote lengthily, from the pen of Canon Walsh, the following description of the destruction of a Kauri forest by fire, because (1) its wordpainting is as good as many photos, and (2) because he points out the slow advent of fire in the Kauri "bush." He is described as a reliable writer and as having had an intimate acquaintance with the Kauri forest.

> In its virgin state the New Zealand bush, with the exception perhaps of the Kauri forest, was comparatively impervious to fire. In recent times since the advent of cattle, however, the bush has been more opened out and is less impervious to fire. The advent of cattle is shown by the shrinking tops of the Rata and the Towai, and in the gradual extinction of the Tawa and more delicate forms of vegetation. This change which has taken place in the quality of the forest has been noticed by old settlers, who remark that when clearing and burning the forest for settlement it is easier now to get a good burn than in the old days. The Kauri bush, which is the most beautiful and valuable in New Zealand, is the most susceptible to fire. The ground around the old Kauri trees is covered with a dense layer of fallen leaves, bark, and humus (*pukahu*), forming a mound several feet in height. These mounds of vegetable detritus once ignited may burn for weeks together, smouldering underneath even when wet on the surface, and piping up with every dry breeze.

Owing to the open character of the Kauri "bush" these smouldering fires will often continue until extinguished by the autumn rains.

> No description, however verbally accurate, will convey an idea of the scene of desolation presented by a Kauri bush after the fire has gone through it. The ground is covered with a deep bed of ashes strewn with fallen branches and with the wreck of the smaller trees. Here and there a giant Rata, its buttressed roots burnt through, has crashed down through everything, and lies with broken limbs and a smoky cavern in its hollowing trunk. The stately Totaras, whose fibrous bark conducted the flames to the tops, when for a moment they became like so many blazing torches, now stand grim and black. The waving tufts of the Toe-kiwi are represented by a coil of snake-like roots. The Fern-tree's feathery fronds and the glossy curving spikes of the Neinei hang shrivelled and limp, while the netted ropes of the Mangemange are gone altogether—vanished in a puff of flame. All the ferns and mosses, the orchids and climbing-plants, all the light and graceful undergrowth indigenous to the Kauri bush, which made the place a fairy paradise, are charred and dead. The Kauris alone seem to have escaped the general fate. With the exception of the more gummy specimens, and those which were exposed to the hottest parts of the fire, they still stand proudly erect, the bark retaining its peculiar silvery sheen, and the head its noble crown of leaves. But this hopeful appearance is only deceptive. The slightest scorching about the root is sufficient to kill a Kauri tree, and though the leaves may remain green for months, as they frequently do, once it has felt the heat of the fire its life is a thing of the past.
>
> The first fire in a Kauri bush may go on for months, and unless a strong wind is blowing, in exceptionally dry weather, its progress is generally slow, and often is scarcely perceptible. But when the second fire passes over it the destruction, only begun before, is quickly completed. By two or three years' time the ground is covered with fallen leaves and twigs and fragments of gum, together with the wreck of the bark, split up and flaked off in thick broad sheets. The sapwood, pierced by the worm and rotted by the action of the weather, is in a condition of tinder. A rank growth of ferns, rushes, and coarse grasses, nourished by the ash, has quickly taken possession of the soil, and helps to carry the fire along. A fire kindled now spreads with frightful rapidity. A roaring torrent sweeps through the bush; every tree becomes a blazing torch, and the whole ground is covered with a sheet of billowy flame; in an incredibly short time all that is left are a few smoking trunks and fallen logs. But the fire has not yet quite done with the Kauri bush. By degrees the fern gives place to the Tea-tree, and, as this is burnt by successive fires, before many years are past scarcely a charred stump remains to mark the site of one of the grandest triumphs of nature in the vegetable kingdom. (Trans. N.Z. Inst., 1896.)

A REALLY BAD FOREST TO PROTECT.

Compare this slow burning of the Kauri forest with that of some forests, which nevertheless have been protected successfully from fire for the last quarter of a century. In an Indian Teak forest the grass is over one's head as one walks—one can just see over it from horseback; the bamboo is 30 ft. to 40 ft. high. This vegetation grows rank and tall during the heat and moisture of the rainy season. In the fierce dry heat of an Indian summer (when the furniture in a cool house kept closed drops to pieces because the glue has had its holding-power dried out) the jungle is an 8-ft.-high tinder-box; and when a spark sets it ablaze the flame rolls on, like a burning wooden house, till it is stopped by a fire-path. The wall of flame may advance at a fair walking-pace, and fleeing before it are the snakes and ground game of the forest. Few of the former escape, and the old-time Anglo-Indian used to regard the yearly jungle-fires as a beneficent law of nature, and quite beyond man's power to arrest. Compared to this the fire-protection of the evergreen forest in New Zealand or South Africa is literally nothing more than children's amusement—a midsummer night's picnic!

The intrinsic danger from fire in Kauri forest is very little. Said Mr. J. Maxwell, the Ranger who has known Kauri forest all his life and the Waipoua Forest for twelve years, "The bush would burn to a certain extent; but the 'gum-diggers' had *carte blanche* for twenty-five years in the Waipoua Forest doing their level best to burn some of it and they burnt very little. When these men were camped in the bush they lit fires at the bottom of some of the trees, but only a few of the trees were burnt. The fire never ran through the forest."—(Forestry Commission.)

FIRE-PROTECTION OF A TREE LIKE KAURI.

A very interesting tree in South Africa, and one with many analogies to Kauri, is the Cape Cedar (*Callitris arborea*). It exudes a translucent resin, has a wide branched crown, lives to a great age, and has a soft, easily worked, durable timber. Though in all these respects very like Kauri, it surpasses Kauri, and indeed has no rival (except Camphor), in its wonderfully scented wood. Like so many of the New Zealand trees, it has two quite different foliages, an early foliage and an adult foliage.

The Cape Cedar tree does not grow in the South African dense evergreen forest, which is sylviculturally the same as the "mixed" forest of New Zealand, and which does not easily burn, but in open dry forest like that of most parts of Australia, and seemingly like that which once grew in Canterbury and which fire has now rendered extinct. On the Cedar mountains where alone this tree grows there is a fair winter rainfall—enough to produce considerable ground herbage and a long, intensely dry, quite rainless summer—so that here are exactly the elements of difficult fire-protection. In the valleys, with irrigation, grow the finest oranges in the world—and I speak with some knowledge of the world's oranges.

The story of the successful protection from fire of this forest is told in "Australian Forestry" (Perth, 1916; p. 35). When I think of the fire-protection of these Cape Cedar forests now successfully accomplished and of the New Zealand Kauri forests, it is like comparing Lake Taupo with the ocean!

COST OF FIRE-PROTECTION.

In India the area put yearly under fire-protection is about 32,000,000 acres, of which the percentage of failure is from 4 to 6 per cent. Much of this area is forest which, from time beyond memory, has been yearly burnt over, fire deteriorating it but not destroying it: indeed, an occasional fire may be good for natural regeneration. The fire-protection work is so arduous that, in spite of labour costing only 5d. per day, the cost of the protection works out to very high figures—from 5s. 6d. to £3 per square mile, the latter figure in the valuable Teak forests of Burmah, where, however, labour is more costly.

In America, as will be more fully seen later, with "lookouts," telephones, patrols, and good organization generally, the cost is only 1d. or 2d. per square mile. In the national forests of the United States of America during the year 1916 the cost worked out to about 1d. per square mile, and the loss averaged ½ acre per 1,000 acres; or, stated another way, the unsuccessfully protected area was 5 per cent. of the area protected, considered during the "rotation" or whole lifetime of the forest.

In South Africa, in the dense evergreen forest like the Kauri and "mixed" forest of New Zealand, the cost of fire-protection is mostly merged in that of organization (see "Australian Forestry," pp. 20 to 44 and 364–365. "When once the forests are organized the cost of fire-protection is almost nominal" (p. 366). The forest in the natural state is little liable to burn. When worked it is at the same time organized against fire. Sometimes the self-protection of the forest is helped by burning off scrub and rank herbage on the margin once in two or three years. Altogether, the cost of fire-paths, of burning off dangerous herbage, and of special watchers for short periods of danger, averages out to 1½d. per acre per year.* This is for valuable forest worked intensively.

In France and southern Europe the position is similar, but with the acute danger there from the long dry summer and the Pine forests the organization must be of the best—viz., good outlook, abundant roads, and always telephones.

PHILOSOPHY OF KAURI FIRES.

The philosophical way to regard fires in a Kauri forest is not as a necessity, but as a bad habit. Fire in a Kauri forest is like the drug habit in man, whether this takes the form of the Englishman's popular drugs, alcohol, tobacco, and tea, or the unpopular ones, such as opium, cocaine, and sleep-drugs. The popular drugs make life pleasanter, do little harm if under control, but in excess hurt or kill. The habitual user calls his favourite drug a necessity. That is the position of fire in the Kauri forest. The pioneers started firing the bush to make room for themselves, and to make the Kauri-logging easier. Then it became a habit, and is now looked on, popularly, as a necessity. Fire, under control, in a Kauri forest is an important aid to natural and artificial regeneration (p. 118). It is the immoderate use of fire that the forester has to combat. There will be difficulty at first in breaking through the fire habit. Fire in a Kauri forest is nothing more than a bad habit—a disastrous habit in the wild Kauri bush, but easily brought under control in the cultivated forest. That was my experience in this class of forest in South Africa. In some of the forest there (Katberg) they got into the habit of burning the bush. Where that habit did not exist there has been little trouble with fire.

As mentioned above—forest-fire protection and how to do it—is fully discussed in my "Australian Forestry" (Perth, 1916). This must be referred to for the routine of the subject.

When I think of the Estarelle Forest, an inflammable pine forest in the dry Mediterranean climate, with the violent hot winds of the mistral

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* Letter, Chief Conservator of Forests, S.Af., 1919

(the fire organization is described at p. 23 of "Australian Forestry"), it seems plain that organization alone would be quite sufficient to protect the Kauri forests from fire—viz., fire-protection would cost nothing more than occasional extra men to put out such small outbreaks as might occur. With good outlook forest stations, such as I have selected for the Rangers' houses at Waipoua* (see the demarcation plan, "Waipoua Kauri Forest"), and the roads and grassed paths of the cultivated forest, I do not think any special fire-paths would be necessary. Any fire that broke out would be seen and pounced on at once.

> A little fire is quickly trodden out;
> Which, being suffer'd, rivers cannot quench.
>
> —"*Henry VI.*"

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* Since the above was written the newspapers (March, 1919) have reported a fire in the Waipoua Forest, the first serious fire for twenty years. Some 200,000 sup. ft. of Kauri was burnt. This was the more unfortunate that steps were being taken to put the forest in order and make it safe from fire. This fire occurred owing to the easily preventable spread of a settler's fire across the boundary. The loss is deplorable; and still more so the continued absence of a Forest Department to guard against further fires in forests more liable to them than the Waipoua Forest.

NATIVE FOREST AND PLANTATIONS OF INTRODUCED TREES.

> "Let honourable members not mistake me. There is no planting. This stand of trees is obtained solely by the art and by the craft of the forester"—Hon. R. T. Robinson, Forest Bill speech, Westralia, 1918.

Comparing the native forest with plantations of exotic trees there are advantages and disadvantages which may be enumerated thus:—

Disadvantages of Planting.—

(1.) The heavy first cost in a country with labour at 10s. or 12s. per day.

(2.) The interest charge, increasing the cost 5 times with 40 years' maturity and 4 per cent. interest. The forest has no interest charge, since the balance is struck yearly, the timber taken out more than paying for the cost of putting the forest in order again.

(3.) The fivefold risk in planting exotics (p. 153).

(4.) Loss of the forest soil in destroying the forest and planting on bare ground. The best proof of the value attached to the forest soil, in timber-production, is the thought and attention given to it in practical forestry. The forest soil is never uncovered without due cause. Its merit may lie chiefly in its fungoid and low forms of vegetation, helpful to root-function.

(5.) Difficulty of planting trees of the "shade-bearing" or "tolerant" class, which in the damp and forcing New Zealand climate are those that may give the best acrim (timber acre-increment).

Advantages of Planting.—

(1.) The early production of timber (not always of the best class), with some very quick-growing trees such as Insignis-pine, Cuban-pine, and many of the Eucalypts.

(2.) The less quick production of good matured heartwood timber such as Californian Redwood, Douglas-fir, and some of the Pines and Eucalypts.

The introduction of the valuable trees of other countries is an advantage which can hardly be exaggerated, but that is common to both cultivated forests and forest plantations. Silviculturally the native forest of New Zealand is crying out for the introduction of quick-growing trees of the "light-demanding" class. The Beech forest notably is without a tree corresponding to the Oak of Europe.

The above advantages and disadvantages weigh to a greater or less degree in every country. Generally, on account of the expense, countries do not plant more than they are obliged to. We have seen that New Zealand up to date has sunk £2,000,000 in plantations of exotics. There would have been a more certain return if this money had been spent in (1) developing the native forest (as in Europe) with roads, (2) the assistance required for a strong natural regeneration, and (3) just such planting as the forest "working-plans" showed to be necessary.

Value of the Native Forest.—It has been shown that even in its wild unimproved state the production of timber per acre from the good native forest of New Zealand is better than that of the wild forest of many other countries, *taking average figures over large areas.* Thus the great Appalachian forests, on the redemption of which the Americans are spending millions, have an average, over the best part of the forest, of only half the timber-stand (15,000 sup. ft.), accepted as the average stand of timber in New Zealand millable forest for the past thirty years (p. 85). And this same New Zealand timber-stand is three times a general average taken over all the American forests, whether public or private, according to both official and non-official statistics (Forest Service Circulars or Bulletins Nos. 171, 140, 83, 167, and Professors Moon and Brown's "Forestry," 1915).

With some, though not with those in possession of all the facts, there has been a general idea that the fine native forests of New Zealand were not worth preserving, and could economically be replaced by plantations of exotic timbers. That is the cardinal defect in the forest policy of New Zealand—so far, alas, as a forest policy can be said to have existed! Though many of the facts which follow have been already mentioned in various connections, it seems desirable, on account of the importance of the subject, to bring them together in the next few pages.

Four Grades of Forest, Natural and Artificial.

Apart from the special cases of (1) Eucalypt plantations (mostly in the north) for railway-sleepers, with Eucalypt-planting generally for farm-timber and house-beams, and (2) suburban forests where, as in Europe, the return may average 50 per cent. or 80 per cent. higher than in good ordinary forests, we may distinguish four grades of economic value among existing forests and forest plantations in New Zealand.

1. *The Native Forests.*—These (as above) include Kauri forests which when put in order as cultivated forests will return £10 or more per acre per year, and permanent settlement at the rate of one family per 75 acres; and in the meantime will give the same return and the same employment as dairying on poor soil. Such forest estates would be amongst the most valuable in the world. They would easily surpass the most valuable national forests in France and Germany—as, indeed, climatically they should. The figures have been set forth above. There are naturally all grades of native forest. We have here only to consider those that are demarcatable. As these can be put in order, usually for a fraction of the value of the timber on them, or at the worst for the cost of grassing, the native forests rank first in economic value. They are free of the risk attending plantations of exotics. Their young timber as it matures should yield as good returns as the same area grassed, and better afterwards. Eventually, normal national forests would pay all present New Zealand taxes, and support, on the soil and in sawmills, about the duplicate of the whole present population of over one million souls.

2. *Californian Redwood, &c., Plantations.*—Californian Redwood, where it will grow well, surpasses every tree now in New Zealand, native or introduced. Its timber may be as valuable as Kauri, its growth as rapid as Insignis-pine! In the Technological Museum, Sydney, a wood sample from New Zealand is the fastest-grown there! I have a photo of its fellow-tree in New Zealand, still growing at Reefton. Californian

Redwood grows well all over New Zealand in moist warmish localities. The finest grove of trees I have seen is near Whangarei. It is the tallest tree on the American Continent, and forms under certain circumstances the densest "stands" of timber. On the other hand, its natural regeneration, except from sprouts, is poor (Sudworth). Young trees can be raised early from cuttings in nurseries. In a fair soil in the Redwood belt of northern California marketable coppice trees 16 in. diameter and 80 ft. high, with an average of 2·4 in. of sapwood, are produced in thirty years. ("The Redwood," Bul. 38.)

For general utility the Tulip tree and two or three first-class conifers come very near Californian Redwood.

3. *Insignis-pine and Eucalypt Plantations.*—These will cost £10 or £12 to form, or more if they are put on to the good soil, which Insignis-pine and Gums generally want for their very rapid growth. But the early maturity of the Insignis-pine enables it to escape a heavy interest charge—at twenty years only 2·2, against 5 at forty years. Insignis-pine will furnish case-timber in fifteen years; and match-boarding, rough timber, and impregnated sleepers in twenty-five years. For very sparsely-grown trees the maturity period would be even shorter, but the timber then would be knotty, coarse, and quite second-rate—sometimes not worth the cutting.

Eucalypts should perhaps be a class by themselves. They do not mature as early as Insignis (or the untried Cuban-pine) and thus yield the same money-percentage return, nor is their success so uniform; but Ironbark, Tallow-wood, Blackbutt, and a few others may yield more valuable timber. This, however, is only in quite the north of New Zealand. The cold-country valuable "Gums" will be discussed later.

4. *Ordinary Forest Plantations.*—These, such as those that have been laid down in New Zealand, should furnish ordinary useful timber. Economically they occupy the fourth place. To produce timber of good quality they must be planted fairly close (6 ft. by 6 ft. the limit), and they will not mature under an average of forty years. Though the risk of planting exotics is reduced by the multiplicity of species, it still exists. The Government timber plantations and Selwyn Board plantations in Canterbury may barely pay expenses with costs (plus interest) of three or four millions.

The Fivefold Risk and Fivefold Interest Charge with Exotics.

Against the almost costless native cutivated forest there is some £13* for planting and maintenance, multiplied by 5 for interest, or £65 per acre. To this has to be added five distinct risks—(1) Risk of acclimatization, (2) risk of failure in early growth promise (as often with Eucalypts), (3) risk of disease, (4) risk in natural reproduction at the end of forty years, and (5) risk in quality of timber. Thus the Blue-gum of Tasmania was that unfortunate country's best forest asset—a first-rate timber; but the Blue-gum in South Africa and southern Europe, California, and India is too often considered only useful for firewood. It has nowhere produced the same fine timber in foreign countries that it does in Tasmania, and the cold country of Victoria.

Larch in New Zealand does not produce the good timber of Larch in Europe: it is less durable and more knotty. Sometimes promising and quick-growing trees will not clean their branches well in a new country as (according to Elwes) Spruce in England, and, often, Insignis-pine in New Zealand.

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* This is the actual figure to date. It may be reduceable to some £10 per acre as is now claimed, but on the other hand there is the constant rise in wages.

The Himalayan Deodar grows well in England, but its timber has little value there; the Laricio-pine timber of southern Europe is not the Laricio-pine timber of England; and so on with a host of introduced trees in Europe. In the best book of New Zealand forestry (Lands Department Forestry Report, 1909, p. 113) Mr. Adams, of Greendale, Canterbury, says, very truly, "Under cultivation some trees will make splendid growth which left to themselves in an ordinary plantation will be dismal failures; of this I could give many instances." Mr. Adams's experience is that of tree-planters in every part of the world. Of the trees that succeed under cultivation only a fraction are useful as forest-trees.

Planted Trees as Nurses for the Native Trees.

The late Mr. Deans, of Homebush, Canterbury, made a series of plantations which as an arboricultural study are without parallel in New Zealand. Some years after his trees had grown up there came quite a sprinkling of native-bush trees, apparently from seed brought by birds. Here it was the light-demanding, quick-growing imported trees that provided the conditions required for the shade-bearing and shelter-loving native trees.

In British East Africa, where the highland forest is but a variant of that in South Africa and much resembles the New Zealand "bush," I made some extensive plantations of exotics in localities where the native forest had been destroyed. They were well picked climatically and grew well at first. Naturally, their future is doubtful. The Conservator now writes to me that their chief use may be as protection for the native forest which now in many places is coming up self-sown under the protection of the planted trees. It would be interesting to obtain an official report from him now on this point.

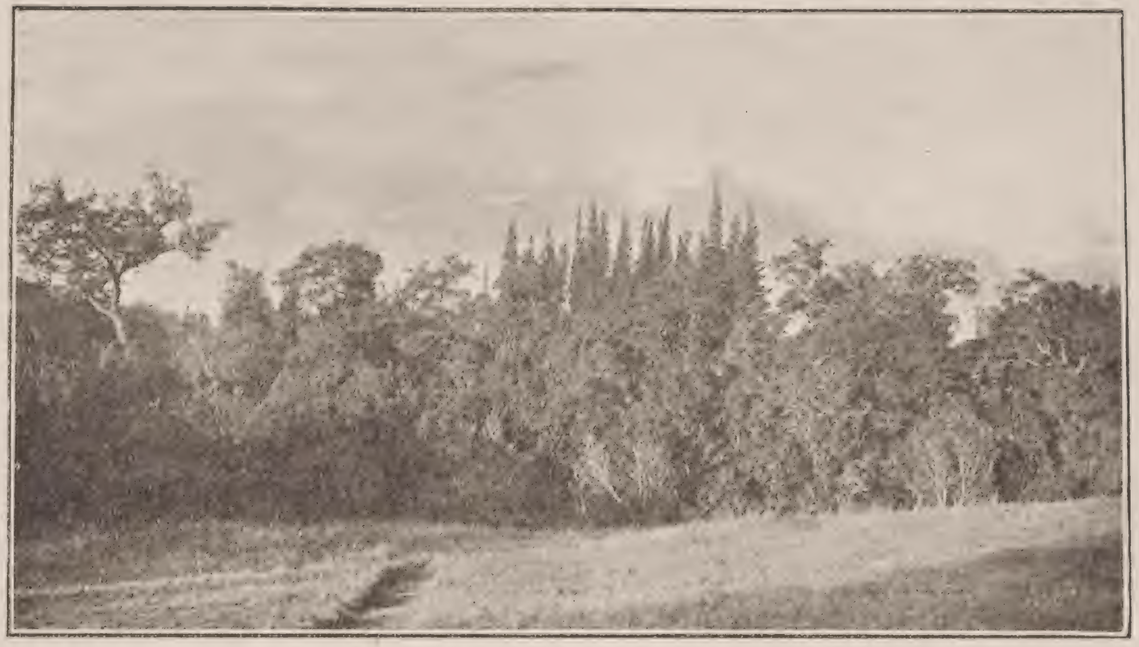
In German East Africa the forest is practically the same, and I have never heard it even suggested by German foresters that the native forest should be cut down and replaced by plantations of exotics.

It is doubtful if the planting of native trees, beyond "standards" in the "bush," could be made to pay. The figures for a Kauri plantation are given below. Totara might be hardier and grow as fast as Kauri, but its timber is not Kauri. Puriri does well in the open, but it is doubtful, with New Zealand labour almost the costliest in the world, whether any of the native trees would repay the cost of planting. This is my experience of thirty years in South Africa, where the cost of labour (at Cape Town and the south-west) is less than half that of New Zealand.

No Risk with the Native Bush.

The best native timber-trees may grow no faster than the ordinary native trees of other countries, but they are sure. They have been where they are since geological time, and provided we leave them in their environment there is no uncertainty as to their rate of growth or the exact value of their timber. It is true that sometimes the native forest, apart from felling, perishes with the advent of civilized man. Fires are extraordinarily destructive in North America, and in New Zealand some forest organization is required to meet them. Introduced insect and fungoid pests in some other countries are serious. Usually,

PLATE XVII.



INTERPLANTING BURNT FOREST, SOUTH AFRICA.

Insignis-pine, over 100 ft. high, Kolagha Forest, Cape Province. Forest silviculturally the same as New Zealand "mixed" forest.

Photo, C. E. Legat.]

[*To face p. 155*

however, it is only very weak small island forest floras that disappear entirely with civilization, its pests, and the stronger trees that follow in its wake. There are not many instances of such disappearances of the native-forest flora. That of St. Helena has gone, but a remnant of the native forest remains in Madeira, sheltered by the invasive Cluster-pine, a tree which is spreading self-sown slightly in New Zealand. But in the small Canary Islands farther north the native forest has held its own against civilization for three hundred years; and, as far as I can see (after a careful study on the spot), it seems likely to do so when not purposely destroyed.

Pessimists and illogical defenders of the present destructive forest policy of New Zealand have urged that these cases of perishing island floras apply to the forests of New Zealand. They read of these things, and apply them hastily to the fine forests of New Zealand, when there is no real analogy. The forest flora of New Zealand is a large, strong forest flora, a member of a geologically larger forest flora. Whether one takes the Kauri forests of the north, the Beech forests of the south and colder regions, or the "mixed" forest throughout New Zealand, there is no analogy with those weak island floras which have been displaced with the advent of civilized man. Give the New Zealand forest only a reasonable chance against destructive felling, grazing, and fires, and it is as strong as the forest of most countries. It is stronger than the native-forest flora of the British Isles, for instance. But to demarcate out isolated scraps all over the country under the name of "scenic reserves," to leave those unprotected, and expect them to last under a Spanish summer sun with the frequent fire-risk seems scarcely reasonable!

STRENGTHEN, BUT DO NOT DESTROY.

In South Africa, where, no long geological time since, the forest was probably nearly the same as New Zealand, and where the "Yellow-wood forest" is strikingly like the New Zealand forest now, civilization has for the last thirty years ceased to appreciably destroy the native "bush." On the contrary, it is being strengthened and improved, though somewhat slowly, by the introduction of valuable timber-trees from other countries. The accompanying photograph shows the growth of Insignis-pine in the "eastern forests" of the Cape. Some half-million exotic trees were being planted yearly before the outbreak of war; the valuable Camphor-tree is spreading, bird-sown; and the Australian Red Cedar is growing better than any planted Cedars I have heard of in Australia. In the west, near the Cape of Good Hope, the native forest was mostly destroyed centuries ago, long before forestry became a science. But remnants of the native bush still remain; and it is curious to note now, on the slopes of Table Mountain, the mingling of dark patches of the completely naturalized Cluster-pine (*Pinus pinaster*) and the glistening sheen of the indigenous white-foliaged Silver-tree (*Leucadendron argenteum*)—both trees cultivated enough in New Zealand to be well known, especially the Silver-tree on the hills around Wellington.

Many foreign trees bear more seed and have a stronger natural regeneration than the New Zealand timber-trees. It is reasonable to suppose that they may eventually spread through the native forest as Gorse, Blackberry, and the host of introduced weeds have spread over the open country. It is possible that some of them may require a little artificial assistance (p. 116). But if so, being all trees selected for good timber and quick growth, they can afford to pay for it.

PLANTED STRIPS.

In New Zealand, with its superb forest climate, a climate which is nearly the same as the Pacific slopes of north-west America, where grow actually the finest Conifers in the world, there seems no limit to the natural regeneration and self-spreading of valuable exotic timber-trees when once introduced. When one thinks of the facility with which other introduced vegetation spreads in New Zealand, it is evident that here, in the future, lies *a golden forestry harvest* for the Dominion. However long it may be necessary to postpone intensive working in many forests in New Zealand, it is evident that in every forest the seed for this golden harvest should be sown without delay—viz., the introduction of planted strips of self-spreading valuable exotics.

In forests worked *extensively* this is the measure which corresponds to the buildings, roadmaking, and other organization in forests worked *intensively*. Imagine the potential wealth to New Zealand if only one-tenth of the money sunk in doubtful plantations of exotics had been expended in planting strips of valuable trees in the "unoccupied third" of the Dominion!

LOW POPULAR ESTIMATE OF NATIVE FORESTS.

It is only natural that a thing which costs nothing and which is often best out of the way (to the farmer almost always so) should popularly be liable to be rated at a low value. But the understatement of the size of the trees by all writers on the New Zealand "bush," from Kirk downward, is not so easy to account for. Instances of this are given in the Inaugural Address of the Forest League, which has since been published and circulated by the league. Bushmen's and millers' figures refer to bole only, and apparently the literary people added something on to these for the total height of the trees and were satisfied. Actually New Zealand trees are among the finest in the world. As has been seen, Kauri holds the record for producing the greatest quantity of timber of any tree on the globe.

The maximum height of the White-pine has been persistently stated at 150 ft.; the actual figure is something over 210 ft. — probably near 250 ft. There is no gainsaying my measurements, confirmed by Mr. Phillips Turner's measurement taken with a theodolite and chain.

When a forester compares the value of New Zealand native forests with those of other countries it becomes clear that the New Zealand forest has been much underrated. Its capabilities of improvement have been lost sight of. Though the New Zealand trees grow faster than European and most American forest-trees—in fact, just as fast as one would expect in the favourable tree-growing climate of New Zealand—it has been thought that they should be discarded in favour of certain quick-growing exotics. Exactly what has been the underestimate of the value of the native forest in New Zealand can be seen by looking again at the table of average timber "stands," showing how well the timber "stand" of the millable forest of New Zealand compares with the best part of the Appalachian forests of America. This table shows the value of the New Zealand forest even in its unimproved state compared to highly valued forests in other parts of the world.

American forests vary more than those of New Zealand. They vary from the heavy timber "stands" of Douglas-fir and Californian Redwood to poor forest in all grades. General figures for the whole of each country compare thus. At page 6 of U.S.A. Forest Circular 171, comparing millable forest, United States of America, with millable forest, New Zealand, average figures show :—

Millable Forest, New Zealand and United States of America.

	Sup. Feet per Acre.
General average figure accepted for thirty years in New Zealand (see also Lands Dept. Forestry Report for 1916, p. 3)	15,000
Reliable estimate of the original virgin forest in United States of America	6,118
Present forest of all classes—public, private, virgin, and regrowth	4,550
Public forests—Federal and State	4,842

From which it will be seen that the average millable forest of New Zealand carries about two and a half times the timber "stand" per acre that there was in the original virgin forest of America, and rather over three times the average timber "stand" per acre in the present forest, whether public or private.

New Zealand and Australia.

Compared to Australian forests, the difference in favour of the New Zealand forest is even greater. That will be readily understood on account of the greater dryness of the Australian climate. In certain wet areas, such as the Karri forest of the west and the *Eucalyptus regnans* forest of the east, there are very heavy stands ("Australian Forestry," p. 106). But to consider the best Australian forest that is left extending over any large area—the Jarrah forests have an average stand estimated at only 2,500 sup. ft. of sawn timber.

Over the reserved forests of New South Wales, which are mostly in the heavy rainfall area of the "Northern Rivers," the Conservator estimates 5,000 sup. ft. as the average "stand." ("Australian Forestry," p. 102.) We have then—

Average Timber Stands.	Sup. Ft.
Millable forest of New Zealand	15,000
Jarrah forests of Westralia	2,500
New South Wales (Cons. Rep., 1913–14)	5,000

Thus one may say that the average timber "stand" over the *millable* forest of New Zealand is exceptionally good compared to the wild forest of other countries taken over any large area. Naturally the New Zealand timber "stand" is inferior to that of the cultivated forests of Europe. Nature has done a great deal for New Zealand. It would be asking too much to expect a fully developed country with roads, railways, and cultivated forests ready to hand!

SENTIMENTAL FORESTRY: AN ANTITHESIS.

In Australia, where the natural forests are mostly hardwoods, of which the utility is restricted to certain employments, the national sentiment is in favour of preserving the forests instead of making softwood plantations. The official journal of the Forest League is called the *Gum Tree*. Yet it is certain that the Australian forest, if it were composed of good softwoods, would have at least double its present value.

In New Zealand, where the forests produce softwoods (nine-tenths of the timber used in the world being softwood), the popular sentiment is in favour of destroying the forests and replacing them by plantations, an exception to this being the views put forward from time to time by a few far-seeing patriotic men, and a sprinkling of beauty enthusiasts, naturalists, and botanists. Valuable though their advocacy has been in saving really large areas of forest, they have not viewed the subject from its economical side. Probably, on the whole, the most useful advocacy of a better forest policy has come from a few timber-merchants and millers, alarmed at the approaching extinction of their industry. It was the millers and hardwood dealers of New South Wales that at last brought about the adoption of a national forest policy in that State ("Australian Forestry," p. 303). As is pointed out when speaking of White-pine, if every dairy-farmer would join the Forest League there would soon be no more talk about getting supplies of butter-box timber from Siberia. And if every miller and bushman would do the same there would be no fear of the extinction of their great industry.

GROWTH OF NATIVE AND INTRODUCED TREES.

The growth of Kauri and some other New Zealand trees is discussed at pp. 10 to 16, and of White-pine later; it only remains to add here that (in the open) some of the introduced trees grow much faster than the native trees, and faster generally in forest plantations. The growth of Insignis-pine, Macrocarpa Cypress, and a few others is at first quite remarkable, and offers to New Zealand a unique chance of repairing, as far as may be in plantations, the thriftless destruction of the native forest. Other introduced trees grow faster at first and slower afterwards than the native trees; that seems to be the case (taking the two most valuable, native and introduced trees) with Californian Redwood and New Zealand Kauri. At other times the New Zealand trees and introduced trees grow side by side at the same rate, as New Zealand Beech and European Beech, New Zealand Puriri and European Oak.

In the municipal planting at Khandallah in 1918 European Birch (*Betula*) planted alongside New Zealand Birch or Beech (*Fagus*, various species) grew up to 4 ft. in a year, while the New Zealand trees scarcely grew 4 in. But what is the sequel? Birch in this climate in France is a *bois blancs*. Its function in nature is to shoot up rapidly and then give way to the great timber-trees. The visitor seeing the happenings of to-day says New Zealand trees are too slow to plant! That may or may not be so. What is certain is that nature may plant all that is required if only given half a chance.

At New Plymouth Botanical Gardens, where is the best example of the growth of introduced and New Zealand trees side by side, the verdict is that there is little to choose between the two, apart from two or three very quick-growing exotics. The trees are grown not under entirely forest conditions, but more so than those in the Auckland Domain. The arboreta required to put the matter to a complete test do not exist in New Zealand. I have collected all the readily available data from planted trees of known age and yearly rings of growth, and these will be published. Details of comparative growth of Kauri and European forest-trees, and of young trees of the chief timbers in New Zealand and Europe, are given at pp. 10 to 19. And it is there shown that, taking the growth of native trees as given at p. 78 of the late Mr. Matthews's book ("Tree-culture in New Zealand"), New Zealand diameter-growth is four times European and height-growth nearly twice. It must be noted that the comparison here made is between native New Zealand trees grown in the open and between European trees grown in a normal forest. Thus the greatest difference is in the diameter-growth.

Judging from the height-growths, and the yearly rings of growth, one can say generally that the New Zealand native trees grow, as would be expected, faster than the forest trees of colder countries such as Europe and America. Since the forests of these countries are yielding returns, in money and employment, equal to dairying on poor soil in New Zealand, and are very carefully preserved and worked, it follows that New Zealand should do the same, unless all the civilized world (with England almost the sole exception) is in error over its forest policy. It must be remembered that Japan, after exhaustive inquiry and sending Commissions to the chief forest countries, adopted scientific forestry *in toto*. In Europe it is only some of the Balkan States that have a forest policy no better than New Zealand: and they are not losing forest like New Zealand.

PRODUCTION OF TIMBER PER ACRE PER YEAR.

When all is said and done, the growth of individual trees only points the way to the forester's real task, *the maximum mean yearly production of timber per acre—the "acrim,"* to use a convenient abbreviation. A quick-growing tree does not necessarily produce the highest acrim. Other things have to be considered.

For the production of timber per acre per year in fully stocked areas, data from the cultivated forests of Europe are readily available. There are also data from regular regrowth forest in America, and from the country most like New Zealand, Japan. For New Zealand these data are wanting; and, so far as I have seen, there are no means of arriving at an estimate that would be sufficiently reliable and of general application. The returns from certain milled areas in New Zealand are known, but the age of every tree felled is different, and the rings of growth would not be clear enough throughout to compute averages, apart from other sources of error, such as the disregarding in the milling of unsound or small dominated trees. It is probable that from the few areas of regrowth forest that have escaped the general destruction an area sufficiently regular to measure might be found. So far I have not seen such an area, but I have heard of them. As the forest becomes regularized and improved such figures will gradually become available. It is safe to conclude they will be favourable for these reasons.

The limiting factors of timber-production are primarily light and moisture, and secondarily the seasons of winter cold and summer drought. The air and space required for each forest-tree in popular writings have no more basis of fact than the heart as the seat of the affections in popular writing. New Zealand has the abundant light of its latitude, and over the greater part of its area a heavy well-distributed rainfall, together with mild summers and winters—all favourable to timber-production. Drought, such as limits the timber "stands" of Australia and South Africa, and even parts of eastern Europe, is absent from New Zealand. Schimper, amongst his many mistakes, misunderstood Brandis and quoted 40 in. rainfall as the limit for really successful forestry. Actually the limits vary according to the latitude. It is about 15 in.

in northern Europe and about 35 in. in the tropics: 25 in. may be taken for the extra-tropics and the North Island of New Zealand. There is thus no area too dry for successful forestry in the North Island, and only perhaps Central Otago and some smaller areas in the South Island. The dull light which thins the timber "stands" of foggy England and northern Europe is equally absent from New Zealand. Thus in New Zealand, where there are mild summers and winters, and rarely a want of moisture, light is left as the sole limiting factor. If the *individual* native timber-trees of New Zealand have a timber-growth greater by 40 or 80 per cent. than those of Europe, it is probable that the increment of timber per acre is proportionately greater still, for in addition to the climatic reason there is the fact that the New Zealand timber-trees belong to the shade-bearing or tolerant class of trees.

SHADE-BEARING AND LIGHT-DEMANDING TREES.

It is the A B C of forestry that all forest-trees are classified as being light-demanding (intolerant) or shade-bearing (tolerant). Lists are drawn up giving graduated scales for each class. For New Zealand trees this knowledge will come with the forestry of the future. In the meantime we know that trees in the New Zealand class of forest, the dense evergreen forest, are usually more or less shade-bearing; and observation shows that New Zealand trees are no exception to this rule.

Shade-bearing trees, *Ceteris paribus*, produce more timber per acre per year than light-demanding trees. This is shown by a glance at the yield-curves given in my "Journal of a Forest Tour." Spruce and Silver-fir grow side by side in the same forests. In pure "stands" Spruce at first shows the higher volume of timber per acre, but as maturity is approached this position is reversed. The light required for one Blue-gum may satisfy half a dozen Silver-firs, and the Blue-gum only produce three times as much timber as one Silver-fir!*

In my album of New Zealand forest views are two suggestive photos. The first photo shows the slow growth of a native tree taken away from its forest home—a Black-pine in the Botanic Gardens, Christchurch, that at forty years of age is 11 ft. high. It has had ample light, garden cultivation, and shows no sign of disease or injury, but, as a shade-bearing tree, is a fish out of water. It is not one-eighth the size of light-demanding trees growing alongside it.

The other photo shows the obverse of the picture—Rimu and Miro trees growing in the dense shade of the native forest at Buller Gorge. They are flourishing in shade so dense that a light-demanding tree would perish forthwith. By test with a photo light-meter I ascertained that these two young trees of Rimu and Miro were flourishing in a light only about one-sixtieth that of full light in the open. The photo-active rays differ from the growth rays, but the one is an indication of the other. A light-demanding tree, such as the common Blue-gum, for instance, wants the full light of these latitudes. I know from experience in planting it in cleared forest that when full light is cut off, only by a little, the Blue-gum shows a reduced growth.

To quote an illustration from the great fir forests of Europe, Silver-fir is a shade-bearer with a heavy "stand" of timber at cropping-time. Whether we take first-class, second-class, or third-class forest, Spiedel's

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* The American Forest Service Bulletin 92, "Light in Relation to Tree-growth," may be consulted. It is by two eminent American foresters—Graves and Zon.

Yield Curves show clearly that Silver-fir is above all other European timber-trees in the final volume of timber per acre. But no native shade-bearer of the New Zealand forest has a much slower growth at first. For the first few years the seedlings are so minute that it requires a practised eye to find them. I shall give the subsequent growth figures elsewhere, but it may be noted that there is Silver-fir forest yielding up to £5 net per acre per year in the French Jura Mountains.

RISK IN PLANTING INSIGNIS-PINE AND OTHER EXOTIC TREES.

Considering the fivefold risk in planting exotic trees in New Zealand it is the Insignis or Monterey pine that first commands attention. The Insignis-pine grows phenomenally fast in Australasia, South Africa, South Europe, California, and South America; and its timber, under reasonable forest conditions, is a useful indoors household deal, taking an antiseptic so readily that it can be easily employed out-of-doors as well. So far as the limited arboriculture of New Zealand extends at present, Insignis-pine has shown itself to be the best general-purpose planting timber in the country. The prejudice which exists against it in New Zealand is mostly due to its being badly grown and to its being compared with better timbers from the native forest. It grows so vigorously and, when closely planted, with so clean a bole that it not only resists fire itself when the thicket stage is past, but can be planted as fire-resistant for other less vigorous-growing trees. It should have been the first tree to plant in the Government timber plantations, though it was actually one of the last.

Acrim.—Mr. S. I. Clarke, builder, of Ponsonby, Auckland, and a member of both the Timber and Forest Commissions, in his paper "Forestry," printed in the *Farmers' Union Advocate* of the 10th March, 1917, states that various Insignis-pine plantations in New Zealand have yielded 100,000 sup. ft. per acre, in nearly every case being cut under forty-five years of age. If one takes 1 cub. ft. = 6 sup. ft. of sawn timber, 100,000 sup. ft. = 16,666 cub. ft. This figure divided by, say, 40, as the figure of mean age, will give a mean yearly timber-growth figure (acrim) of 417 cub. ft. Similar maximum acrims from small areas on good soil have been reported from South Africa.

Price.—Insignis-pine sells on a royalty of from 2s. to 5s. the 100 sup. ft. of mill-output to travelling sawmills in Canterbury and Waikato. Kauri timber is worth two or three times Insignis-pine timber, and Kauri has a world-wide market. Where native timber is obtainable Insignis fetches very little, so that the Insignis-pine market is restricted. Thus, although Insignis may have three times the timber-growth of Kauri and mature sufficiently for its purpose in one-fifth of the time, it may easily give a less valuable return in timber.

Exaggerated statements of the yield of Insignis-pine have been published. In New Zealand, in Australia, and in South Africa the general figures for the best plantations sold at war prices have approximated to £400 net at the end of forty years, or £300 net profit at the end of thirty years. On this a yield of £10 per acre per year has been claimed. This is a hasty and wrong conclusion. One has only to turn to a forest rental table to see that £400 net profit at the end of forty years is equivalent (omitting fractions) to a yield of £4 per acre per year, not £10.

Mr. J. H. Davison, of St. Leonards (Canterbury), has plantations of Insignis-pine as good as any in New Zealand. They were quoted by Mr. A. H. Cockayne in his article on Insignis-pine planting in the New Zealand *Agricultural Journal* for 1913. Mr. Davison cut his plantations in the most profitable manner, and put the timber on to the good Canterbury market. But he assured me lately that successful as his Insignis-pine plantations had been, they had not paid the rental value of the land they occupied!

There are localities, such as certain drift sands and perhaps also pumice land, which are of low farming-value, where Insignis-pine planting will give a good return; but, except for timber of poor quality cut very young, careful calculation is necessary to determine the exact profits of Insignis-pine planting. Speaking generally, one may say with confidence that an ordinary Kauri forest to-day on its regular poor soil is worth more financially, *after cutting out all the mature timber*, than an Insignis-pine plantation on soil of average farming-value. A Kauri forest with a good gradation of ages in the timber is really worth £10 net per acre per year (or £250 per acre capital value) at present timber-prices, as soon as a *forester's* axe goes into it. Puhipuhi, from all accounts, had such a gradation of ages. Waipoua and Wara have not, their timber being mostly old. But with many wild forests the trained forester is able to work out a gradation of age-classes at an early date—that is the business of the *aménagiste* or "working-plans" officer.

Better grades of Insignis-pine as grown by foresters will produce better prices, but it is clear from the above that Insignis-pine planting may easily turn out less profitable than the interplanting of Kauri.

Rainfall.—In New Zealand Insignis-pine is more of a climatic exotic than at the Cape of Good Hope, and though it grows so well and so strong in small plantations in New Zealand, there would be some risk in planting it pure in extensive forests with the summer rainfall of New Zealand. It is a tree of a dry summer climate, and in a wet summer climate may carry a fungus risk analogous to Larch in England. *In its native home the average rainfall is 17 in.*, mitigated by abundant sea-fogs (Sudworth, "Trees of the Pacific Slope"), so that the risk of fungoid trouble in planting it in a rainfall of 70 in. is manifest. Yet it is in this rainfall where some of the best-grown trees in New Zealand are at present to be found (the Waimamaku tree, as above, at twenty-five years is 3 ft. diameter by 90 ft. high); though without doubt by far the greater number of the well-grown Insignis-pines are in half this rainfall, as those at Christchurch, Nelson, Napier, and the Wanganui coast lands.

Disease.—In Australia the usefulness of Insignis-pine decreases just in proportion to the increase of summer rainfall. In Natal, with purely summer rains, its timber turned out so poorly and it was so liable to disease that its planting was tabooed twenty-five years ago. In its native climate of winter rains near Cape Town it grows vigorously, but insect and fungoid disease have even there interfered with its planting on a large scale. Here there is a 40 in. entirely-winter rainfall. In South Australia, where it had been planted pure over extensive areas (in a summer climate too wet for outdoor grapes), a fungoid disease, *Diplodia* sp., threatens it seriously ("Australian Forestry," p. 257); but in the usual dry summer climate of South Australia it holds the record for all Australasian forest planting. The best planted trees in Australasia are those at Whyte Park.

Even the sparsely planted trees of roadsides and house-grounds in New Zealand often show signs of disease. A proportion of the trees at Wellington lose a good deal of their foliage each spring with the arrival of warm wet weather. It is worse in the north, killing the trees in some places. And, according to some American opinion, over all the Insignis-pines in New Zealand hangs the spectre of the terrible "White-pine blister-rust" getting in.

Soil.—Insignis-pine does not usually prosper on very poor or shallow soil. Over a large part of Australia it is held to be a tree that will only grow well on good soil. At Cape Town it fails decidedly on poor sandy soil, but it succeeds on good sandy soils such as those of New Zealand and California. It takes a stunted form on shallow rocky soil or over clay on the hills round Wellington, where the native bush once grew so well.

The mountainous ground near Wellington once carried good native forest; the remains of the native trees show that to a certainty. The forest was destroyed in pre-demarcation days; with the forest went also the rich forest soil, the accumulated riches of centuries; and now the Insignis-pine seems not the best tree for reforesting the Wellington hills. With certain exceptions, it only grows well where the soil may be too valuable for planting it economically.

Says the Western Australian Yearly Forest Report for 1916 (the first from a trained forester).—

> Insignis-pine, which has been planted for the past seven years here, and which now covers 594 acres, has not done as well as was expected. The soil is of too poor and sandy a nature for a species like Monterey-pine, which requires good soil.

Insignis-pine in the Devonshire-like climate of the Government plantations at Tapanui shows signs of declining vigour. Much of it is rat-tailed, some diseased. R. G. Robinson when in charge there gave me as his opinion that forty years was about its limit of usefulness. That is the common Australian verdict.

Natural Regeneration.—The natural regeneration of Insignis-pine is good sometimes in New Zealand, but generally inferior to that in drier climates. ("Australian Forestry"). In the absence of dry heat, the cones will remain on the trees tightly closed for many years. It is generally easy to find such cones in New Zealand, the seed perished without the cone opening.

In the temperate climate of Wellington Insignis-pine seedlings are very rarely seen. In the warmer dry climate of Rotorua they are common; and about Lake Taupo, where it is warmer and drier still, the natural regeneration of Insignis-pine is one of the sights of the country-side. Insignis natural regeneration is seen on the Canterbury Plains; it is believed to be quite absent on the very wet West Coast.

DIVERSE OPINIONS ON INSIGNIS.

In the comparatively dry climate of the Canterbury Plains Insignis-pine grows as well as anywhere in New Zealand. In the official text-book of New Zealand forestry (Lands Department Forestry Report, 1909), Mr. T. W. Adams, of Greendale, gives his opinion of the timber production of Insignis-pine in these words: "All these different (softwood producing) trees from Europe and America have been introduced into New Zealand; but I venture to say that *Pinus insignis* will produce twice as much timber per annum as any one of them." He might have added "in half the time." Indeed, the remarkably rapid growth of Insignis-pine in New Zealand has had an unfortunate effect in distorting the forest policy of New Zealand. It will scarcely be credited that some people, seeing the rapid growth of the Insignis-pine, have reconciled themselves to the destruction of the Kauri forests—viz., to destroying magnificent forests of the finest timber-tree in the world for risky and costly plantations of a tree that is only worth cutting when there is nothing better at hand. Says the Hon. D. Buddo, "I take great exception to growing *Pinus insignis* for profit. I have some in the North Island—Hawke's Bay—4 ft. diameter and 120 ft. high, I can't give away; it is a poor timber for any purpose."

Nevertheless, taken for what it is worth, the growth of Insignis-pine is undoubtedly one of the assets of forestry in the Southern Hemisphere. Handled by foresters it produces a timber good enough for all the ordinary purposes for which coniferous (deal) timber is used, and it takes an antiseptic so easily that it becomes capable of a very extended use. According as grown it may resemble Poplar-wood or Pitch-pine!

The development that this nearly extinct Californian Pine has taken in the Southern Hemisphere seems to be due to the fact that as a planted tree it is generally put on good soil, and that it responds marvellously to favourable conditions. It will show 1 in. rings of growth both in its old native and in its new habitats. Mr. Waller, who went recently from New Zealand to San Francisco, made at my request special inquiries into the conditions of growth of Insignis-pine in its own country. He writes to me,—

> While in California I called on Mr. John McLaren at Golden Gate Park and saw the sand-drift there. I also spent a week at Pacific Grove (Montreal), where I met Professor Perce, the Botanist at Stanford University. He told me that the reason why *Pinus radiata* is so limited in natural distribution is due to its many natural enemies, fungus and grubs. It grows on poor white sand, and it is not nearly so luxuriant as in New Zealand, where it is planted on better soil and is free from enemies. It has been introduced to redeem the sand which was bad in Golden Gate Park, as well as in other places. I saw a photograph of the site of this park, and it was bare sand. Now it is a very beautiful park.

Thus the limitations of Insignis-pine in New Zealand for general planting purposes seem to be—(1) The summer rainfall and a fungus risk; (2) its soil requirements; (3) its rather weak natural regeneration.

STONE-PINE (*Pinus pinea*).

That valuable tree of the Mediterranean, described in some detail in "Australian Forestry," found its way to Cape Town about 250 years ago. There, in the Mediterranean-like climate of its native habitat, it flourished better than I have seen it in Spain and Portugal. Noble avenues of Stone-pine trees led to the old Dutch farmhouses about Cape Town; but about thirty years ago, in spite of the nearly rainless Cape summer, it was attacked by a fungus allied to the potato-blight, which at once ruled out Stone-pine as a forest-tree. There are indications that the tree is gradually becoming able to withstand this pest, but it is doubtful if it will ever again be a tree hardy enough for forestry.

In New Zealand it should find its place in every dry warm corner of the extra-tropical part of the Dominion. It grows fairly as far south as Blenheim. It is a valuable nut-tree. Near Valladolid I went over one of several factories where the nuts are shelled. It dealt with about 1,000 tons per year, and the shelled kernels fetch £84 per ton in Barcelona. In Spain valuable nuts and beautifully clean pasture go together—a double story of productiveness! Stone-pine yields the most delicate and valuable of all nuts. A soft-shell variety is in cultivation and comes fairly true from seed.

FAILURE OF STROBUS-PINE (*Pinus strobus*) IN EUROPE.

When, as a boy, I walked into the forests of central Europe I used to wonder why they did not plant more of this fine pine—the great "White-pine" of America. It grew faster than the native trees, more regularly, and kept the soil cleaner. Where, then, was the risk in planting it? I knew that there was little planting done in the regeneration of the forest, but this fine tree seemed really worth the cost of planting, which was then only some £3 per acre. But the older men shook their heads; they continued planting, but cautiously. This valuable pine grew well for over two centuries in Europe. Then a European fungus, called *Cronartium ribicola*, captured it, a little fungus growing on Gooseberry and Currant bushes. Acclimatization was still imperfect.

Now the Strobus-pine has almost ceased to exist as a practical forest-tree in Europe owing to the attacks of this fungus. This was bad enough, but worse was to follow. It spread to America.

At this moment the White-pine of the eastern States, U.S.A., the forest-tree that has made more wealth than any wild forest-tree, is threatened with extinction. It is considered worth while spending £500,000 (some estimates say £1,000,000) in the attempt to check the spread of this disease. With the young forestry of America, White-pine is the only tree that has been studied silviculturally and put into cultivated forests, like European forest-trees. It is stated that all the pines in the three- and five-needle class are liable to take the pine-blister disease. The total stumpage value of such pines in the United States of America is estimated at £100,000,000.

Silviculturally the Strobus-pine is perhaps the best of all the trees planted in the Government forest plantations at Rotorua. How long will it last? Perhaps just as long as a neighbouring farmer does not walk near it with dirty boots! Or it may be a century before the Gooseberry fungus reaches New Zealand. Mr. Goudie in the Rotorua plantations is taking no great risk: he is not planting White-pine largely. It may be noted that gooseberry has run wild in the South Island, increasing the risk for Strobus, Insignis, and other pines there.

SPRUCE AND LARCH.

The common European Spruce is a climatic misfit in the Northern Island of New Zealand, and soon failed there; but it grew well in the South for forty years, and may still be seen growing well in isolated places, but in the extensive Government plantations at Tapanui it has failed largely, and has had to be replaced by other trees. Climatically fitted it will probably do well in the Southern Island.

Sitka Spruce has had a similar history in Belgium, but the failure there is not complete, and in Scotland Sitka is growing to perfection. It is failing on the Canterbury Plains of New Zealand, but should never have been planted there. It may do wonders in the mountain forests of the South Island, or it may continue to get its disease there.

European Larch in the colder parts of New Zealand usually grows fairly rapidly for fifteen years; it then begins to get "leaf-fall," grows slowly, and is commonly dead or dying at forty. The Forest Commission's report of 1913 was the end of it as a tree for planting in the Government timber plantations. What is said to be the best Larch in New Zealand is at and near Homebush, Canterbury—Mr. Deans'. This at forty years is still healthy and strong, but the fencing-poles split from it have not shown durability.

When an exotic tree has passed the cultivation test and has been moved into the grade of a possible forest-tree, foresters proceed cautiously with it. They feel their way like a ship in a fog. That will doubtless be the attitude of New Zealand forestry with regard to the planting of exotic timbers generally. It must be so with crops that take from forty to eighty years to mature and cost (with interest) from £50 to £230 per acre to plant.

PLANTING *VERSUS* NATIVE FOREST OF KAURI.

Though increasing the stock of Kauri in a Kauri forest, by interplanting some 100 to 300 Kauri standards to the acre, can easily be shown to pay handsomely; whether a full artificial plantation with some 2,722 trees to the acre (4 × 4) would be remunerative may be a debatable point.

Kauri does not seem to grow well alone. As has been said of Oak, "Kauri pure is Kauri poor"; and if this be true, what tree should be planted with Kauri? Supposing a suitable nurse-tree to plant with the Kauri were found, and that the Kauri carried a timber "acrim" of 114, which is average Spruce cut at 100 years in Europe (Schlich's vol. 3), that would mean a total of 11,400 c. ft. of Kauri for the axe at 100 years of age; and 11,400 c. ft. at 2s. per cubic foot royalty would represent a return of £1,140 per acre.

If planting Kauri (with upkeep to the age when thinning equals maintenance) cost £15 per acre, that, with interest at 4 per cent., would amount to £757 at the end of 100 years.

Thus, provided the planted Kauri has "bush" conditions and grows well, and provided Kauri timber rises in price to 2s. per cubic foot (16s. 8d. per 100 sup. ft.), which is about double its present price, and a moderate price to look forward to a hundred years from now, it might pay the State to make regular plantations of Kauri. The returns from a normal forest would be about 10,000 cub. ft. q.g. at 2s. = £1,000 per acre. There would be further returns from resin and from the accompanying timber-trees, thus leaving a good margin of profit after making full allowance for accidents.

But the figures discussed above for interplanting Kauri as standards in the native bush are so much more favourable—from one-fifth to one-tenth the cost of full planting (pp. 130–132)—that, so far as bush can be secured for the purpose, interplanting standards seems likely to be always preferred. This is an additional reason for demarcating and preserving Kauri "bush" of every sort, even Tea-tree or Manuka scrub.

In the Waipoua and other forests Kauri is associated naturally with Tawa and Taraire. As associate trees for Kauri the planting of Tawa or Taraire might pay expenses. They are both fast-growing trees, and are both useful timber-trees that have been mostly overlooked but are now finding their market.

Said Mr. W. B. Leyland in his evidence given to the Forest Commission (p. 49), "Taraire grows very rapidly. Eighteen years ago I planted a Taraire for ornamental purposes, and it now measures 38 in.

in girth. The Taraire will grow anywhere, and it is a very useful tree." A diameter-growth of just under 13 in. in eighteen years for one of the two chief associates of Kauri has an important silvicultural significance. Tawa in the north is also a fast-growing tree. These trees with their rapid early growth might give as good an interest return as Kauri; or, if it came to planting, some exotic trees might give a better return, Tulip tree seems to be one such. Of course, in such cases the Kauri would be planted some years before the shade-bearing secondary species, and most of the thinnings would be in the secondary species.

Similarly, ordinary full plantations of Totara may reasonably be expected to yield a fair return, but interplanting standards would make the profits larger, and the work, silviculturally, a much sounder proposition. Mr. Matthews planted 400 acres with Totara at Puhipuhi, but he had the temerity to plant them entirely in the open, on soil deteriorated by burning, and overrun with fern. This is the only example known to me of planting New Zealand native trees on any large scale. These Totara trees failed from the first and were eventually burnt.

Puriri, as a sleeper or hardwood house-beam, would probably be worth 2s. per cubic foot a hundred years hence. In a plantation it could not compete with some of the fast-growing and valuable Eucalypts, so that its artificial propagation seems limited to interplanting or small patches of planting in the native forest.

Thus it seems that as long as Kauri, and perhaps Totara, grow well it is safe financially for the State to plant them; but the planting of all other native trees is a doubtful venture even for the State. The private planter, without the national forest organization against fire, &c., would run more risk in planting Kauri; nor would he ordinarily care to wait a hundred years for a return; nor has he indirect national advantage to consider like the State.

Forest plantations are a heavy expense in every country. There has been comparatively little planting in the forestry of Europe, less in India, and so far America has accomplished but a fraction of its planting programme. In New Zealand, with labour at 10s. or 12s. per day and rapidly rising, it is evident that interplanting "standards" must generally be preferred by foresters.

FORESTS *VERSUS* PLANTATIONS: VARIOUS ISSUES.

This is a matter which has been much discussed in New Zealand, and, apart from sentiment, generally decided in favour of plantations of introduced trees, because they grow faster at first in the open, being trees which have been brought forward (mainly by nurserymen) for the private planters' work in the open. They are undoubtedly some of the best trees to plant for this purpose.

When, however, we pass into the forest it is like passing into another country with another climate, and no forester would care to say much about what trees are likely to give the best lasting results with forestry the *tabula rasa* that it is at present in New Zealand.

COMPARATIVE YIELDS.

Though the New Zealand wild forest can usually be regenerated and put into order for little if anything more than the cost of grassing, while full forest planting has cost, with interest at 4 per cent. for forty years, some £65 per acre; it will be at once objected that the plantations may yield two or three times as much timber per acre as the indigenous forests and in half the time. But this is a one-sided calculation if, with natural regeneration and a sprinkling of planted standards, from 20 to 30 acres of wild forest can be put into good yielding condition for the cost, with interest (£65), of making 1 acre of plantation! Why pull a house down when all it wants is some repairs? asks the prudent man!

It is difficult to say which may have the greatest value in fifty years—the forest put into order by funds from the sale of its mature timber and now growing up into a well-stocked forest fit to cut in another thirty or fifty years, with its natural regeneration certain; or the plantation with its doubtful natural regeneration and fivefold risk. Broadly speaking the matter should be presented more in this way: *Every tree cut by foresters in the working of a forest is so much gain, every tree planted is so much cost* piling up at interest to a ruinous figure where labour is as high as in New Zealand. When a forester thins a forest there is a double gain—the value of the timber from the trees that are thinned, and the increased increment put on by the remaining trees after thinning. If a dozen trees standing close together really want thinning, and if the forester takes out four of the most crowded, he gets the timber from his four trees, plus a better production of timber than he had before from the remaining eight trees. (See note on Trounson's Kauri Park in "Waipoua Kauri Forest.")

Within very wide limits, an acre of ground covered with trees will have the same timber-production whether the acre has more or less trees on it. The first forest valuation survey I ever did was a good illustration of this. It was Blue-gum planting in southern India. The bulk of the forest was tall, straight, clean poles running some two thousand to the acre; but there was also a piece of poor, sparse planting with only about a hundred trees to the acre. Yet the yield of timber from the two was about the same: the difference lay in the quality of the timber. Sparse Blue-gum timber is often not worth the cost of felling and breaking up for firewood.

FOREST OR GRASS.

The point, discussed in the "Balance-sheet of a Kauri Forest" (p. 95), that it may cost about as much to destroy the native forest and put it under grass as to plant up the native forest to the extent required to give it a full stocking of good timber, shows that the choice, as a matter of national policy and production, is not between grassing and the present forest of New Zealand, with its partial timber stocking, but *between the cultivated forest fully stocked with timber ana the same area grassed.*

Going a step further, there may be doubt about the permanency of the grassing; there is none about the permanency of the forest. There are lands where the grassing is easily permanent; other lands where, with every care, it dies out. Over large areas of what was once good grass land on the fertile southern coast lands of South Africa, the native grasses with sheep-grazing have died out and been replaced by "Rhenosterbosch" and other weeds, as has happened in many districts in New Zealand. But the forest, which has existed for geological time, will continue to exist—provided, of course, it is protected against the artificial destructive forces of civilization, the axe and uncontrolled grazing and fires; and there is no difficulty in doing that so soon as the forest is organized and put under the ordinary forest regime. This has been proved by the third of a century's experience in the treatment of this class of forest in South Africa: *vide* the quotation given above (p. 89) from the classic printed and circulated by the South African Government, Sim's "Forest Flora of Cape Colony."

Surveying and Roading.—To the cost of grassing has to be added the cost of surveying into lots. Thus the Tutamoe Forest, with comparatively large lots of 500 acres each, cost about 3s. per acre to survey.

Roads are wanted in either case—roads costing up to an average of 1s. to 2s. per acre per year in Europe for fully developed forests; roads in New Zealand for land developed either for dairying or timber. But this has to be remembered: that the cream-cart has got to run almost the year through, while summer-grassed roads with brushwood in the ruts will answer most purposes in the forest.

THE INTEREST CALCULATION.

Then comes the interest calculation. When we take this at 4 per cent. for forty years for ordinary forest plantations, and multiply by the factor 4·8, we take this as low as it is possible to take it. In the natural forest all the interest calculation goes out. When you plant a tree in a plantation the interest charge runs on till that tree is cut, supposing that thinnings balance cost of maintenance, which they may not always be able to do. But in the natural forest there is no interest charge under normal conditions, since the timber-increment is being produced throughout the whole of the cultivated forest; and whether it be an even-aged forest in compartments, or an uneven-aged forest with working at intervals all over, when a tree is taken out its timber-increment is immediately supplied automatically by the surrounding trees, without spending a penny.

FOREST PLANTATIONS ELSEWHERE.

It has been shown that in European forestry, planting is limited most commonly to places where natural regeneration fails. Forests where artificial regeneration is now employed will become less as the price of labour rises. The ordinary visitor is often misled as to the amount of planting actually done. He sees numerous nurseries, with their files of buxom girls at work in them, and naturally runs away with the idea that those nurseries represent the general practice. The English prejudice against healthy, light outdoor work for women and children enhances the cost of forest nursery-work in New Zealand. But the forestry loss here is less than the national loss, for the physique of these lady forest workers is magnificent, and their domestic and educational attainments not to be surpassed by town workers. Something near half the number of forest employees are women and children in some European States—Bavaria, for instance. (*Vide* Statistical Appendix, Part II.)

In South Africa extensive plantations were a necessity. The area of natural forest was not above 300,000 acres all told, and much of this with a very low timber-growth figure; while the cost of labour and the value of land were scarcely half those of New Zealand.

ILLUSTRATION OF THE POSITION.

An illustration is perhaps the readiest way of showing the contrast between natural forests and forest plantations in New Zealand. To cut the natural forests down, instead of turning them into the ordinary cultivated forests of other countries, resembles the action of a man of eccentric habits who, inheriting a substantial family mansion of much beauty and greater value, but wanting some modern improvements, becomes tired of his noble inheritance and burns it down—to replace it, at ruinous cost, by a structure that cannot at best be more than a cabin compared to the mansion he has recklessly destroyed.

If a forest-concession hunter or other adventurer were to propose to civilized Governments nowadays that their native forests should be cut down and replaced at enormous cost by plantations of untried exotics, such an adventurer would be classed along with the flat-earth people or other monomaniacs!

After three years in New Zealand I may claim to speak with a slender but sufficient knowledge of the forests. My previous life has been spent in acquiring a practical knowledge of some forests in Europe, Asia, and Africa, with a book knowledge of American forests. My opinion is that, on the whole, New Zealand forests may be classed as above the average of forests elsewhere. The Kauri, as seen, is unique in the world as a timber-producing tree.

I have not attempted in the above pages to conceal the defects of New Zealand forests. I freely admit that they would have a considerably increased value in the cultivated form. That happens elsewhere. Consider what scientific forestry has done for the wild forests of Europe, from Spain to Russia. Let it be always remembered that in Prussia, where careful statistics have been kept, it is on record that in a man's lifetime of seventy-four years the timber-yield has been increased nine times, and the net money yield more than ten times (*vide* Statistical Appendix, Part II). The State forests of Saxony have increased in net yield per year sixfold in ninety-six years—from 4s. per acre to £1 4s.

My natural bent is towards exotics. I have spent the best years of my life planting them in South Africa. The all-too-generous eulogy of the Canadian forester, R. H. MacMillan, is proof of this ("Forestry Quart., Dec., 1916). And in discussions with foresters I have championed times out of number the introduction of "better trees of other countries." But I cannot now resist the conclusion that to go on destroying the forests of New Zealand, because in their present form they are not the best in all particulars, would be like flooding or setting fire to the coal-mines because they are not the best in the world! There is this difference between the forests and the mines: As soon as the forests are worked by foresters they start improving; as soon as the mines are worked they start depreciating, and too often in Australasia they are finished at about the time that national forests would be coming into their full yield—a yield which goes on increasing with the wealth and population of the country.

PRESENT PUBLIC FOREST AREA OF NEW ZEALAND 10½ MILLIONS.

The present total area of forest in New Zealand not Maori or otherwise privately owned, according to the latest official returns, is 10½ million acres, and of this only a small fraction (under 1½ millions) is as yet under nominally protective forestry. According to European standards, New Zealand should have some 16 million acres permanently under forest, but on account of the mountainous character of so much of the land the higher Japanese standard is indicated, this being necessary to secure the highest production from the land and the largest population on it.

As has been seen, it is to national forests worked up gradually to the European standard that New Zealand may look, in the next generation, for bearing the cost of this war and eventually much other taxation as well. As in Europe, national forestry means national wealth. This is the lesson drawn from European forestry—first by India, then by Japan, then by South Africa, then by the United States of America, and now, within the last few years, by the most advanced of the Australian States. Is New Zealand to remain always in the background?

FOREST ALIENATION.

SOME 30,000 ACRES OF BUSH LAND ON POOR SOIL (DEMARCATABLE FOREST) BEING ALIENATED YEARLY.

THE table below shows the areas on which exemption from rent and local rates has been obtained on the ground that the bush is on poor soil and would not otherwise pay to deforest. The return has the advantage of embracing figures estimated and checked by Crown Lands officials for the purposes of money grants and the yearly statistics. It therefore does not represent loose estimates, seen in other returns of bush land.

The area of bush land (all probably demarcatable forest) alienated and getting these exemptions during the last fourteen years has been 690,510 acres of heavy bush, 139,321 acres of light bush, and 92,143 acres of scrub, or a bush-land total of 829,831 acres. The abstract below shows that under the stimulus of rent-remission, and the rush to take up poor bush land rent-free, for periods varying from two to four years, the heavy bush alienated during the first four years amounted to 567,963 acres, or at the rate of 141,991 acres per year, while the light-bush land amounted to 129,951 acres, or at the rate of 32,488 acres per year. Since then, from 1909 to 1918, the alienation of heavy bush has averaged 12,255 acres per year, and light 13,192 acres per year.

Transactions under the Bush and Swamp Crown Land Settlement Act, 1903 (now embodied in Section 127 of the Land Act, 1908).

Year ended 31st March.	Area selected during the Year.			Remarks.
	Heavy Bush.	Light Bush.	Scrub.	
	Acres.	Acres.	Acres.	
1905 ..	132,779	54,112	20,855	Act in operation from 30th October, 1903 ; return for one year and five months.
1906 ..	139,670	36,164	23,437	Total rent remitted during year, £7,034, of which £5,236 was on heavy-bush land and £975 on light-bush land.
1907 ..	181,378	26,391	37,870	
1908 ..	114,136	13,284	6,564	
1909 ..	13,268	..	..	
1910 ..	18,466	..	..	Rent remitted, £2,017 only.
1911 ..	10,308	..	..	Rent remitted, £878 only.
1912 ..	21,524	..	..	In the Wellington District.
1913 ..	665	..	..	,,
1914 ..	..	..	..	
1915 ..	23,257	..	..	In the Nelson District.
1916 ..	21,512	2,579	2,370	
1917 ..	10,583	4,771	1,047	
1918 ..	2,964	2,020	..	Rent remitted, £122 only.
Total..	690,510	139,321	92,143	
Average	49,322·2	9,951·5	6,581·6	

This is independent of Maori land and Maori felling-rights, which, with the sanction of the Maori Land Board, can be freely alienated.

The above figures may be held to point to between 20,000 and 30,000 acres as the yearly alienation of demarcatable forest. The average for heavy and light bush combined is 59,273 acres per year. But the figure for the first four years must be considered to represent the rush to secure bush land which, with the remissions, it might pay to deforest and grass. The last two years of low figures may be due to war conditions. It must be considered (1) that there may be a proportion of demarcatable forest not rated as poor enough to deserve exemption; (2) that during the period 1909 to 1918 no large area of bush land was thrown open. When the recent purchases in the Urewera country take effect these figures will mount rapidly. For these reasons I rate the current alienation of demarcatable forest at about 30,000 acres yearly.

It has been shown above how the cost of opening up these forest lands for timber-working and gradually increasing settlement would in most cases be paid for (1) by the standing timber, (2) by the timber-growth increment (acrim) resulting from the conversion of a wild forest (carrying no timber-increment) to a cultivated forest—such cultivated forests being of more certain value to the State than costly plantations of risky exotic trees.

It may further be of interest to compare this value for the alienation figure—viz., 30,000 acres—with the area, 24,000 acres to 36,000 acres (the latter perhaps more correct), lost yearly by destructive instead of conservative working in the timber reserves (Yearly Report, Lands Department, 1916, p. 3). It may also be compared with the total area of the Government timber plantations formed during the last *twenty-three* years—viz., about 35,000 acres.

FOREST ALIENATION IN THE "CROWN LANDS GUIDE."

A study of New Zealand Crown Lands Guide—say, that corrected to 1st July, 1917—is the best proof of the sort of forest alienation now going on. Thus at page 29 one sees high mountain land described as covered with "bush" or "heavy bush" and offered for sale at about 10s. per acre. At page 39, in Westland, forest with Rimu, White-pine, and Silver-pine at about 11s. per acre—Silver-pine being intrinsically per cubic foot about the most valuable timber in New Zealand. Much of this land is weighted with the cost of previous attempts at misguided settlement—partial burns, partial fencing, and partial ditching. Again, at page 43: Run 445—"the whole of the upper watersheds of the Cook and Balfour Rivers; very wild country, mostly bush": 20,000 acres here at a yearly rental of £10 for the 20,000 acres!

In Marlborough (p. 27 of the Guide) one sees the proposed alienation of the precipitous mountain forest lying above the Blenheim–Nelson main road. It rises to an altitude of 3,600 ft. A total of 11,852 acres, in eight lots, is offered for outright purchase at £4,790, or an average price of **6s. 3d.** per acre, classed as second- and third-class land. The forest is Beech, with "mixed" in the valleys.

The forest below in the Rai Valley has been worked for thirty years, and was only finished two years ago. Opinions are divided as to whether this fine forest, with its water frontage and easy water access to Wellington, should not have been kept as forest. But with regard to the steep mountain ground above it there are no two opinions. It cannot be kept in permanent grass by ploughing: it is nearly all too steep for ploughing. Timber can be brought down the mountain-side and taken across economically from Pelorus Sound to Wellington. It is one of the best areas for the supply of timber and firewood to Wellington; and here is *nearly 12,000 acres advertised for sale at 6s. 3d. per acre*, an amount which is about one-third of what it would yield per acre per year as forest at no distant date.

In the Auckland District, at pages 6 and 7 of the Guide, are long lists of good mountain forest offered for sale at about £1 per acre, in lots of from 500 acres to 1,500 acres. Much of this is scheduled as "heavy mixed forest," and goes up to altitudes of 2,700 ft. above sea-level. On pages 2, 3, and 5 is more good mixed forest on poor mountain land. Here also is some Kauri forest. Thus at page 2, second-class land on Great Barrier Island, small Kauri, Puriri, &c., 114 acres for £60! (Naturally it is the small Kauri on which the forester sets store.) Again, on page 2, Section 3, "mixed forest comprising scattered dry Kauri (only sufficient for settlers' requirements)," 178 acres for £135. Generally where there is dry Kauri there are Kauri seedlings, but of this naturally there is no mention. The next description of Kauri forest for sale is more explicit: page 5, Section 275, Whangarei County, "mixed forest—a few Rimu trees and Kauri rickers"; 78 acres for £80: abandoned by a former settler, and now weighted with £25 valuation for grassing and fencing.

Again, in the heart of the best Kauri country, within three miles of the Wairoa River, where the Kauri would possibly be restorable at a small price, 75 acres of third-class land for £30.

Any one applicant may obtain 2,000 acres of such forest classed as second-class land, or 5,000 acres classed as third-class land, or any balance of such areas not already held by him.

This is the present position of forest alienation disclosed by the Crown Lands Guide, drawn up as it is from the point of view of indiscriminate destruction of national wealth without forest demarcation.

The indiscriminate alienation of forest land in New Zealand was always dangerous. It is now ruinous. It is admitted on every side that New Zealand now wants all the forest that is left to it. Yet the war which has brought about revolutionary changes in the forest policy of England and Australia has as yet induced only partial forestry reform in New Zealand. Said a respected citizen of Akaroa to me lately, "My son has 800 acres of heavy-bush land in the Urewera country, for which he paid the regulation price of 25s. per acre. It is magnificent forest, and the destruction of it is a shocking sight. He would save it if he could, but under the terms of his purchase has no choice but to destroy it." Said a witness to the Forest Commission of 1913 (p. 16 of Report), "Sale plans have passed through my hands covering thousands of acres of heavily-timbered land, and not an acre has been set aside as a reserve."

It is difficult to arrive at even an approximate estimate in money of what New Zealand is now losing yearly in the absence of the usual forest demarcation of other countries—of Victoria, of New South Wales, and of Westralia, for instance.

At 30,000 acres yearly it would mean that every year that forest demarcation is postponed and the present indiscriminate forest alienation continues there may be a loss to the country to be looked at in two ways:—

(1.) Somewhere near £1,500,000 to replace the yearly forest alienation (if that were ever done) with plantations of exotic timbers—since 30,000 acres × £50 = £1,500,000. I take £50 per acre as the probable cost of future planting—viz., first cost and maintenance and interest to forty years, but it may be too low considering the constantly increasing cost of labour. Actual planting-costs in the past plus increased cost of labour in the future would make the figure about £2,000,000.

It will be said forest plantations may yield two or three times as much timber as the native forest. That may be true for the first forty years; and then the economic position may be reversed, because by that time the forest may be fully stocked, have a timber-growth figure approaching the forest plantations, and a better natural regeneration. The crux of the matter lies in the fact that in forty years the present forest plantations will have cost the country some £65 per acre, while the forest all this time has been giving good returns, perhaps yielding as much money and employment as would have grassing and dairying, on the poor soils to which forest demarcation generally relegates the forest.

(2.) As native forest the loss to the Dominion may represent an even greater value. Puhipuhi, as has been seen (p. 68), represented a value at present-day prices of **£720** per acre. No such forest exists nowadays; but we may fairly take somewhere near **£300** per acre as representing the value of good existing forest, reckoning the values of both present and future timber crops. This maximum value of £300 per acre would mean a forest well stocked now, and (what is more important to the calculation) with a good standing stock of young immature timber. (See photo of Kauri forest at Matakohe: frontispiece). One must remember that under existing methods only the present-day merchantable timber is ever considered, while the best value may be in the immature timber which will ripen as the countryside develops with roads and markets. From this maximum value of about £300 per acre there are naturally all grades of value in the forest being alienated. Both (1) the present timber-value, and (2) the discounted value of future timber crops, will vary with each forest; since (1) depends not only on the present "stand" of timber but on the means of working it, while the value of (2) depends on the grades of the younger forest, the distribution of the age-classes.

Thus, as an illustration, if one assumes that the average forest being alienated may have a mean value of only one-tenth of the maximum, or a value in present and future timber crops of only £30 per acre, there comes out the awkward little calculation—30,000 acres × **£30** = £900,000; or, as a round figure for a low estimate, **£1,000,000,** so that the absence of forest demarcation may be costing New Zealand some £1,000,000 yearly in present, and the discounted present-day value of future, timber crops.

These figures do not mean that there is one million's worth of timber being lost yearly, but that the forest alienated, if worked scientifically, would represent that sum *as a present-day value*. From this has to be deducted the value of a few good crops of grass raised on the ashes of the burnt forest, and (on the poor soil of demarcatable forest) uncertain grass thereafter.

The £1,000,000 Value discussed.—The forest values of which £30 per acre is merely a rough general estimate are not future values subject to a heavy discount for time. They are present values, *realizable with interest* after a certain number of years, depending on the quality and age of the forest concerned. But from these values would have to be deducted the cost of putting the forest in order, which at the worst would be the cost of interplanting; at the best, the thinning-out of the mature timber. In most cases the cost of putting the forest in order would be balanced in a few years by the opening-up of the forest and the marketing of its products. Always it is demarcation, forestry, and settlement that is contemplated. It is settlement and working that puts the value on to the forest. The best forest with a proportion of old timber and much smaller timber would yield handsome returns in perpetuity as soon as the axe was put into it by foresters. The worst forest, Manuka or scrub, interplanted with quick-growing exotics would give some return (less cost of interplanting and interest) in thirty or forty years. Forest where a sufficient natural regeneration of native trees could be secured would give immediate returns and a full crop in from 60 to 120 years. The maximum value is that of such a Kauri forest as was Puhipuhi, where there was plenty of young timber and which would in a few years be making £10 per acre per year net. New Zealand has still probably Totara forests that would do nearly that. Ordinarily there is a transition period of much lower yield, as worked out in "Balance-sheet of a Normal Kauri Forest" (p. 95). Puhipuhi in present and discounted value of future crops had an immediate value of £720 per acre (p. 68). Thus when I take £30 per acre as the average potential value of the present demarcatable forest I am perhaps making too low an estimate. In New Zealand, where land is so valuable, it is obviously widely incorrect to estimate the value of the forest only from the present crop on it, which is largely a matter of accident. Just as an experienced farmer is wanted to appraise farm-land values, an experienced forester is required to appraise forestal values.

After demarcation the treatment best suited to each forest would be settled by the "working-plan" or *aménagement*, and that would indicate the financial position of each forest. At present it is happily not necessary for New Zealand to concern itself much about the £1,500,000 loss, the cost of full planting in the open. But it is the sword of Damocles hanging over the country, and every year of heedless bush alienation brings it nearer.

This figure of £1,500,000 lost yearly, if the forest had to be made good by forest plantations, may be considered with the *£1,383 per day* (Forestry League address, p. 2) that New Zealand was paying for imported timber before the war; and with the figure, three or four times as much, of indirect loss in various trades consequent on the increasing dearness of their raw material, timber and bark—house-building, furniture-making, leather-making, and (with national forestry) papermaking. If we add these two items* together, which is the logical sequence, the country may be out of pocket by £3,000,000 yearly, as the result of reckless forest alienation without expert forest demarcation.

Less Costly to sacrifice the Forest Plantations than to alienate First-class Kauri Forest.—If, owing to political causes or the natural conservatism of a distant and isolated community, it should so happen that the present unreflecting forest destruction should proceed to a still further extreme, there is no escaping this conclusion: it would be more economical to cut down the forest plantations than any of the remaining first-class Kauri forest. For the average yield from first-quality cultivated Kauri forest cannot be less than £10 per acre per year, and may be more (p. 98). The most sanguine planter of introduced trees (and I reckon myself one) would not estimate an average yield from the forest plantations of anywhere near £10 net per acre per year as a net rental value.

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* £2,000,000 cost of plantations to reforest (p. 175) and £1,000,000 the value of present and discounted future timber crops of forest alienated.

The country must have timber—that has been recognized in sinking over £2,000,000 on the existing timber plantations; and yet, on the basis of this plantation expenditure, the country is losing some £2,000,000 yearly in alienating demarcatable forest. This waste of natural resources seems hardly to have been paralleled during the worst days of American forest history. As shown in Part II, the American reckless forest waste was stopped long before the country had reached the present forest condition of New Zealand.

The New Zealand Class of Forest in Africa no longer alienated.—In Cape Colony forest alienation came to a definite end with the establishment of national scientific forestry in 1883. Under British rule the best forests in South Africa, those of Knysna and George, were being cut up into lots and sold. By 1853 twenty-nine large forest lots out of 158 surveyed for sale had been alienated. Then in the nick of time came responsible government; and with the first Parliament the sale of the national forests was stopped, never to be renewed as a matter of public policy, though there was a continual leakage of small areas, with the sale of farms which "a bit of bush" improved. This went on till the advent of a Forest Department and the final definite demarcation of the forests in 1881.

No Forest Alienation in East Africa.—There is good forest of the New Zealand class in East Africa. At 8,000 ft. under the equator it differs little from the sea-level forest in South Africa in the latitude of northern New Zealand; and it is enriched by a fine Cedar from the highlands of Abyssinia. Here is the tropical bridge between the northern and southern ex-tropical dense evergreen forest, furnishing an interesting field for speculation in forest geography. The late colony of German East Africa got the largest share of this forest

As soon as British East Africa started developing its temperate-climate highlands an Indian forest officer was obtained, and the forest demarcated. In 1906 came the rush of white settlement, and a detailed and restricted forest demarcation became necessary. I was called from South Africa to do it.

In 1910 I was sent on a forest mission to German East Africa. I found that the Germans had already got their forests better organized than we had, with surprisingly good forest stations ("Waipoua Kauri Forest," p. 32), with roads, and some plantations of exotics; and I ascertained that their forest demarcations had been mostly completed within a few years after Bismarck took over the colony, while all alienation of good forest had definitely ceased some years before my visit.

The timber-working was equally modern and thorough. At one lift I was carried in a cage up an aerial timber cable-way, from a railway nearly at sea-level, to a well-timbered plateau lying at an elevation of over 6,000 ft. above sea-level. This was in the Usambara Mountains. (The official report of this visit might usefully be added to the forest literature in the Parliamentary Library.) All this fine country, with a great botanic garden imitating Buitenzorg, has now fallen into our hands.

MNEMONIC.

If yearly thirty thousand acres they alienate,
Of good, or at least restorable, forest,
And wait but a year to demarcate,
It's one[*] plus two[†] millions lost, at some date.

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[*] Because, taking £30 as an average value of present timber + discounted future timber crops, £30 × 30,000 = £900,000.

[†] Because, if it came to replanting, £50 (cost of planting + interest) × 30,000 acres = £1,500,000, or, at actual rates of planting in the past, £1,950,000: say, with the rising cost of labour, over £2,000,000.

RECAPITULATION.

The Kauri Tree.

Largest Timber-tree in the World.—Investigation soon showed that the Kauri tree, in addition to its sterling qualities as a timber, was the largest timber-tree in the world—not the largest in outside measurements, but the timber-tree that has given the greatest volume of timber.

The Mercury Bay tree, with 24 ft. diameter, which figured for long in New Zealand literature, has been allowed to be burnt before accurate measurements were recorded.

The largest well-authenticated measurements on record are those of the tree called "Kairaru," in the Tutamoe Forest, of which the diameter was 22 ft. and the clean bole 100 ft. high (Kirk's "Forest Flora"; H. P. Kavanagh, late Chief Inspector of Timber, Auckland; and W. B. Buckhurst, Crown Lands Ranger, Christchurch). This tree cubed out to above ⅓ million sup. ft. taking its full volume, and rather below ⅓ million sup. ft. taking its quarter-girth volume, or its volume by the ⅔-diameter-squared log-rule of the United States. The largest of the "big trees," termed "Mother of the Forest," in the Calaveras Grove had a gross volume, according to the published official measurements, of 140,619 board feet, so that the *largest of the Californian "big trees" contained less than half the timber of the recorded largest big Kauri of New Zealand.* The big trees of California are decidedly higher than the highest of the giant Kauri trees, but there is not much difference in diameters, allowing for the very thick bark of the Californian trees, the thin bark of the Kauri trees, and the huge basal spread of the Californian trees. The New Zealand giant Kauri trees eclipse other large timber-trees on account of the little taper in the trunks. It is quite common, amongst photos of the old-time Kauri trees, to come across trunks with no taper at all. The largest of the two "Yellow-wood" trees of South Africa (*Podocarpus elongata*) has a bole of similar shape. I know one other tree with the same form—the "Pillarwood" of the equatorial highlands of Africa. Both these cube out to less than a fourth the maximum of the big Kauri trees.

Kauri Resin or "Gum."—The systematic resin-tapping of Kauri remains as a subject of investigation whenever a technical Forest Department is formed. So far as can be seen at present, systematic tapping of Kauri for resin is likely in the future to be an extremely lucrative business. It is possible that the resin from a Kauri forest may be more valuable than the timber, as is the case with Maritime-pine in France, and with some other trees that yield valuable resin. There is no reason to suppose that the resin-tapping of Kauri, if skilfully conducted, will injure the Kauri timber or appreciably affect the growth of the trees. In France it certainly improves the timber, and in moderation is thought by some foresters to stimulate the growth. It is possible that Kauri may be planted and a Kauri-resin industry established in various parts of the world's wetter extra-tropics. The resin is peerless and quite unlikely to be replaced by any chemical product. The Kauri tree grows at much the same rate as the famous Maritime-pine in Gascony; the yield of resin is greater, and commands a higher price. The Gascony pine forests are valued at £20,000,000 (Reconstruction Committee, 1917). As a result of the British no-State-forest policy applied to New Zealand, nine-tenths of the Kauri forests have been destroyed without any attempt being made to establish an industry on the Gascony model.

Kauri Tree of the Future.—Misapprehension has been caused by assuming that the economic size of the Kauri tree of the future must be the same as that of the large trees cut out of the virgin forest. The typical tree aimed at by foresters in central Europe is about 1 ft. in diameter and 60 ft. of bole, though in Sweden, and rather exceptionally in other countries, commercial milling takes trees down to 8 in. and even 6 in. diameter. It is probable that the most useful size of the Kauri tree of the future will be 2 ft. or 2 ft. 6 in. diameter, with 60 ft. of bole, and it will reach this size in about a hundred years of age; but there may be little or no loss in allowing the Kauri trees to grow to a rather larger size, because at that age they are growing very rapidly, especially in the upper part of the log.

THE KAURI FOREST.

The Remaining Kauri Forest.—The original Kauri forest was no doubt as irregular as virgin forest of this class elsewhere, and as one sees it to-day in a nearly original state at Waipoua. Speaking generally, the best forest has been *destroyed instead of being worked and preserved for the Dominion.* The comparative poverty and inaccessibility of the Waipoua Forest have been the chief factors in preserving it.

Two types of Kauri forest are discussed in the preceding pages—(1) The ordinary type of Kauri forest, such as the Waipoua Forest, which will not be fully stocked as a normal forest for about a hundred years (p. 97); (2) the rich Puhipuhi Forest (p. 55). The richness and accessibility of the latter brought about its destruction some twenty years ago. At present-day Kauri stumpage (or royalty) prices, in round numbers, £4,000,000 was the *lowest possible* value to put on the public loss when the Puhipuhi Forest was destroyed. In the study of that forest I have uniformly taken the lowest possible figures. This £4,000,000 is made up of two sums—(1) the value of the old-time Puhipuhi Kauri timber at present-day prices (less a small sum recovered in royalties); (2) the capitalized value of future timber crops that could have been got from the forest straight-away with scientific working. The area of the fully stocked Kauri forest was 5,667 acres—an area equal to the upper part of Wellington Harbour cut off square by a line through the main building on Somes Island. The rest of the forest only partially stocked with Kauri was double that. 17,000 acres was the area of the whole reserved forest.

After a hundred years of "forestry turned inside out" the proportion of Kauri trees in the remaining Kauri forests is now very low indeed, though not so low as Teak in the Teak forest of India. Happily, in even the poorest of the present Kauri forests, the proportion of Kauri can be readily increased by the comparatively inexpensive process of interplanting Kauri standards—a hundred or two hundred to the acre—up to three hundred to the acre where there is no Kauri at all now. The analogy in regular foresty will be with the "coppice-under-standard" forests of France, where Oak stands over Beech, Hornbeam, Birch, Elm, and smaller trees. New-Zealanders, when they visit France after the war, should make a point of studying these forests. It is estimated that, working systematically in an organized forest with good roads, standards could be planted and cared for till their heads were definitely beyond the danger of being dominated, at a cost per acre ranging up to £3. In such operations "well-timbered acres" in the forest of to-day would far more than pay for "bad acres." The balance would be struck yearly: there would be no interest charge on the cost of putting the forest in order. That has been the general scheme of forest improvement in the cultivated forests of Europe.

Apart from a few specially reserved Government Kauri forests, two or three years will see the end of the Kauri timber, but that happily is not the end of the Kauri forests. Some areas show quite a satisfactory natural regeneration in spite of partial further fires and grazing—indeed, light grazing may be beneficial to Kauri natural regeneration. Larger areas are restorable at moderate expenditure. Land of this sort on the western side of Waipoua, extending nearly to the sea, has been included in the demarcated area. Many of the present patches of millable Kauri one sees to-day are clearly regrowth forest after former forest-fires.

It is estimated on good authority, and that estimate is supported by a study of the coloured "Land Tenure" map of 1916, that quite half a million acres of Kauri forest might still be saved with a policy of liberal demarcation and redemption, the Kauri-timber crops from such area being calculated as sufficient eventually to fully pay all possible charges on the war debt—viz., 500,000 acres, with a yearly net revenue of £10 per acre, would yield the State £5,000,000 yearly. The bulk of this half-million acres would be in the Coromandel Peninsula and Hokianga.

THE KAURI FOREST OF THE FUTURE.

These calculations depend on the yield to be expected from the cultivated forest of the future. With a study of the growth of Kauri and other timbers in the present forests of New Zealand, and a knowledge of forest similar to it in India, East Africa, and South Africa, and using the yield-tables of long-cultivated forests in Europe, approximate figures for the normal Kauri forest of the future in New Zealand can be worked out. These may be expressed in general terms thus:—

Normal Kauri Forest.

Average age of the main timber crop	100 years.
Average number of trees per acre in the first main timber crop (about)	100 trees.
Average cubic content of each tree (boles only) ..	100 cub. ft. q.g.
Acrim (= average production of timber per acre per year)	100 cub. ft. q.g.

These figures are smoothed to represent general averages. It is remarkable that they should all come out so near the figure 100.*

Something like this would be the normal forest to be kept in view during the next 100 years. Thence onward it would be gradually improved, the number of Kauri or other first-class trees doubled or trebled, and the acrim raised to nearly 200. The forest would pass from the "coppice-under-standard" type to that of a regular high forest *futaie* in even-aged compartments. This is an operation that has been going on in French forests for over a century. When completed it will raise the productiveness of French forests to a level with German forests, though it will lower the forest interest-rate earned. See an interesting account of two French forests now under conversion treatment —Chaux and Faye de la Montrond, in the Jura Mountains—by H. R. MacMillan, the well-known Canadian forester, in *Forestry Quarterly* for December, 1916. The forest of Chaux was divided into compartments as far back as 1724, and the gradual conversion to high forest (*futaie*) began in 1766.

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* These figures may be conveniently memorized in the following tag:—

When the forests of Kauri get their ten-guinea stocking
The old-time destruction will seem rather shocking.
One hundred years, one hundred trees of one hundred cube q.g.,
Will give one hundred "acrim" in a two-feet sixty tree.

The tree here referred to is 2 ft. in diameter at breast-high, and has a bole of 60 ft.

FINANCE.—THE BALANCE-SHEET.

With the above data it has not been difficult to draw up a general balance-sheet of revenue and expenditure for a normal New Zealand forest, taking European figures for the cost of work increased to correspond with New Zealand rates of wages. The figures given in the balance-sheet (p. 95) are the basis on which stand the various proposals for forestry in New Zealand made in this report.

Revenue.—In most classes of New Zealand timbers—in Kauri absolutely—prices have doubled during the last fifteen years. The balance-sheet assumes that in 100 years from now timber-prices will have again doubled. This estimate may be too much for second-class timbers such as White-pine and Insignis-pine, but there is little doubt of its being realized in the case of first-class timber such as Kauri. The general timber-yield figure (acrim) for the normal forest has been assumed at 100 cub. ft. q.g. But there is no doubt that, though it may be no more than this at first, the final definite figure will be nearer 200 cubic feet.

Thus three values—a maximum, a minimum, and a mean value—can be taken for the future revenue per acre of a normal Kauri forest.

Forest-revenue Estimates.	Net, per Acre per Year.		
	£	s.	d.
Mean value (adopted in this report), assuming a doubling of present timber-prices in 100 years, together with a yield figure (acrim) of 100 cub. ft.	10	16	0
Minimum value, assuming no rise in price and a 100 acrim ...	5	16	0
Maximum value, assuming double present prices and a 200 acrim	20	0	0

In this report I have adopted the mean value (p. 98), but there is no doubt that future generations may look forward with confidence to a realization gradually approaching the maximum value. The revenue from the present standing timber and thinnings up to 100 years from now will depend naturally on the class of timber and prevailing age. I have attempted a rough generalization in the balance-sheet.

Forest-revenue figures from Europe and other countries are given for comparison. Thus, in the well-known Black Forest on the Rhine I saw in 1913 small areas of forest with an average net revenue of over £5* per acre per year. Comparing these forests with their climates and timber-prices, the advantages are all on the side of New Zealand.

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* Whole forests have net yearly revenues averaging over £3 per acre Thus Pfalzgrafenweiler (part of Black Forest), 7,000 acres, at average altitude of 2,000 ft., with 71 miles of roads (of which 45 are metalled)—£3 10s. 7d. Farther south (Jura Mountains), in the latitude of Dunedin, a French forest of Silver-fir and Spruce, with similar roads—La Forêt de Levier—£3 3s.

Expenditure.—Here the balance-sheet speaks for itself. It deals only with figures which may be regarded as rough general guides in the case of a Kauri forest of average quality. In practice, the figures in each forest will be settled after a "working-plan" has been drawn up and approved by the Minister, in consultation with his technical adviser. There may be forests—suburban forests, for instance—where on national grounds the Government may decide on a heavy expenditure of borrowed money. In France the general situation is that the accessible forests are paying the cost of working and improving the inaccessible forests, leaving on the general Forest Budget a surplus of about £1,000,000. On certain alpine forests, to stop torrents and erosion, there is an expenditure far beyond what the forest can ever return.

The balance-sheet starts with the first working of the wild forest, and ends with the forest in full order as a cultivated forest, yielding certainly a great deal more: in the case of Kauri perhaps eight times as much as the wild forest (p. 83). The immediate financial position hinges naturally on the present condition of the forest—viz., whether it is mostly old timber or whether there is a good supply of younger timber that will come forward rapidly with the thinning-out of the older timber. At the very worst, with no young timber in sight and little prospect of natural regeneration, the native forest can be fully interplanted with standards for about £2 per acre, as against £10 to £13 the cost of making an entirely new forest by means of a full timber plantation in the open.

Natural Regeneration.

Outside the ordinary method of thinning the forest and letting in light, ten artificial aids to natural regeneration are described. How far it may be economical or advisable to apply any of these artificial aids will depend on the circumstances of each forest, in practice on the *aménagement* (working-plan), and the character of the season during the year that each *coupe* (felling-area) is being cut over. The three essentials for natural regeneration are seed-bearing trees, light, and the soil in order.

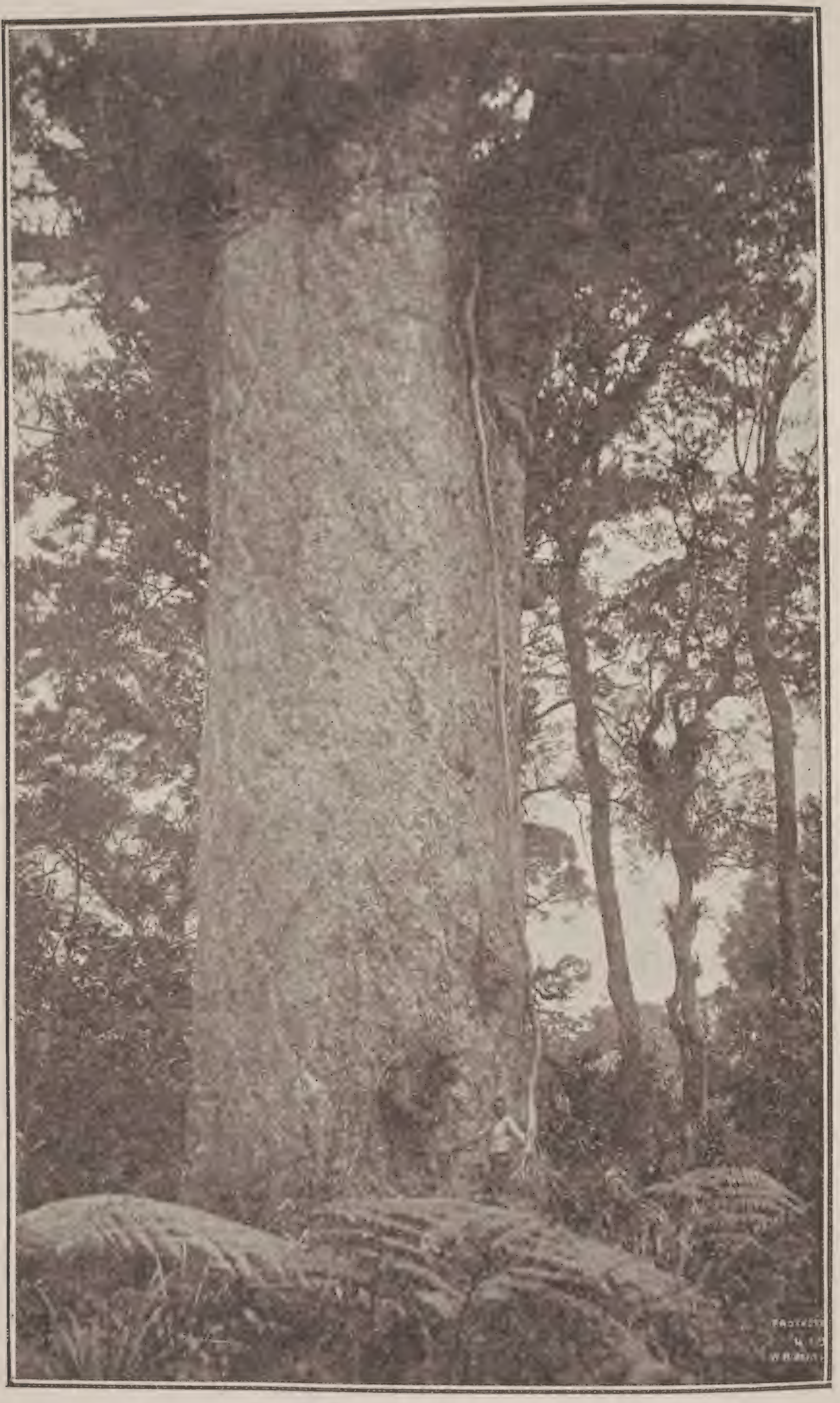
Interplanting.

There are areas in New Zealand, as in all wild forests, where seed-bearing trees of good species are deficient or perhaps wanting altogether; and in all the forests it is very important and of particular interest to bring in the introduced trees and leave them, when once established, to nature—to see how they comport themselves. Hence the urgent necessity *of interplanting not only Kauri but also introduced trees in the Kauri forests, and similarly Totara, in other northern forests.* The trees I recommend for interplanting are described, for the northern forests, in these pages; for New Zealand forests generally, in Part II.

As compared with full planting in the open, costing £8 to £12 per acre, interplanting a limited number of standard trees may cost from £1 to £3 per acre. No pitting, cleaning, rabbit-fencing, stem-pruning, or thinning is necessary; and fire-protection costs less. There is required only *perhaps* mulching (or a disc weed-stopper) and *certainly* one or two inspections to see that the standards are not dominated before they get their heads through the canopy.

Planting in the bush has the further advantage of providing shelter, and that modicum of shade which nearly all young forest-trees like, together with a soil that at its poorest cannot be so bad as some of the soils available for planting in the open.

Plate XVIII.



New Zealand had the finest Softwood Forests in the Southern Hemisphere.

A massive Kauri tree, 17 ft. diameter and 44 ft. bole (figure, 5 ft. 8 in.). Taper diameter 5 per cent. only. Mr. Trounson knows no thicker recent Kauri in New Zealand. It was burnt twelve years ago in a bush-fire which ran on to it from a neighbouring worked forest. The photo of this tree was shown at the Auckland Exhibition.

Photo, W. H. Bartlet.] [*To face p. 183.*

Strips of Self-spreading Trees.—The introduction of valuable foreign trees is a special feature of interplanting. A portion of such exotic trees may be expected to spread naturally as introduced vegetation of other kinds has spread in New Zealand. This is an important measure of general forest policy throughout the forests of New Zealand, and as such will be discussed more fully later. Whether these exotic trees spread naturally or not, whether the growth and quality of the timber is all that is expected or not, the cost involved is small compared to that of making regular plantations of exotic trees.

EMPLOYMENT AND SETTLEMENT.

A careful official inquiry has shown that employment on the purely pastoral sheep-runs of New Zealand averages only one man per 3,003 acres. Looking at land-settlement too much through British spectacles, it has been supposed that all the forest lands should be turned into pasture and thrown open for settlement. The map of Europe shows a very different picture from that of the British Isles with its sad rural depopulation. In the Rhine Valley, probably the best cultivated and most highly industrialized part of Europe, the area under forest is about one-third of the total area, and over the whole State of Baden it is 38 per cent. This is well shown in the two extracts from Phillips's large-scale war-map of Europe at p. 188.

Two facts must be grasped: (1) Timber can be grown in the well-cultivated forests of central Europe to compete in the open market with timber being brought from wild forest in America and from half-wild forest in Sweden and Hungary; (2) these cultivated forests of central Europe give employment at the average rate of one man working throughout the year per 105 acres. (Details will be found at p. 94.)

Taking the shorter and warmer working-day of New Zealand, this is equivalent to one man per 75 acres. The balance-sheet shows how easily a cultivated Kauri forest could support this charge, and still contribute to the State at the rate of £10 16s. net per acre per year. In all calculations in this report employment in *fully* developed and cultivated forests is therefore reckoned at the rate of *one man per 75 acres*. Such State-forest employees are settled more permanently on the land than most farmers; they earn more than the average dairy-farmer, and, settled in model hamlets, escape the isolation and monotonous life of the isolated farmer. In Europe forest-work in winter and farm-work in summer is the usual practice. This increases and varies the year's work, rendering it so much more profitable that the small farmer in France and Germany, assisted by his forest winter earnings, is better off in health and pocket than the corresponding townsman.

UNDERRATED VALUE OF THE NEW ZEALAND FOREST.

Australians describe their Eucalypt forests as the finest hardwood forests of the world. That may be true, but hardwoods have at best only a secondary value on the world's markets. In many countries the hardwoods in the forest are not considered worth cutting. The world uses some nine softwood trees for every hardwood tree. If the Australian forests had been mainly softwood instead of hardwood, the destruction of the New Zealand softwood forests would have been of less importance to the timber-markets of the Southern Hemisphere.

New Zealand had the finest softwood forests in the Southern Hemisphere (see Plate XVIII), and can still keep that position if the reckless past could only be definitely broken with. Properly handled the softwood forests of New Zealand should be the country's premier natural asset. Actually the Southern Hemisphere with its huge areas of endless pastoral plains wants softwood forests much more than grass! And in the near future it will pay a higher price for forest products than for pastoral products.

Unhappily in New Zealand shortsighted and nearsighted views have prevailed. Up to this war England had managed fairly without the State forests of other civilized countries—not caring overmuch for keeping the people on the land, and placing commerce before home production. England is a grass country: why not make New Zealand a grass country? The forests are not of a type familiar to Europeans, therefore call them "bush" and valueless. For sixty years the popular Press repeated the dictum of the "man in the street" of every country—that the trees of the forest grew too slowly for him or any one else. It is now eighty-four years since Charles Darwin said Kauri was the most valuable production of the North Island, but it is only six years since Cheeseman's investigations went to prove this. New Zealand forest has been systematically underrated, though 15,000 superficial feet mill-output has been accepted as the average stand of the millable forest of New Zealand for forty years. Campbell-Walker quotes this figure, and gives the mill-outputs from which he drew his conclusions. The Lands Department publications frequently refer to the same figure. It was verified recently (Forestry Annual Report, Lands Dept., 1915–16). Now, this figure (15,000 sup. ft. per acre) is twice the average timber "stand," taken over the better parts, of the great Appalachian forest tract, for which under the "Weeks" Act the Americans have paid 2¼ millions as a matter of forest redemption. Again, 15,000 sup. ft. as a "stand" of timber is two and a half times the average "stand" estimated for the virgin forests of the Continent of North America, and three times the estimated average timber "stand" of the present forests, whether public or private. One can even carry the comparison into the cultivated forests of Europe! 15,000 sup. ft. from a New Zealand mill (some 3,000 c. ft. in the forest) is the equivalent of the normal timber "stand" of the common Pine of Europe—viz., Scotch-pine—in medium-quality forest at age 58!

In its own class the New Zealand forest stands supreme. The timber "stand" is better than that in the virgin forest of South Africa, better than that in the same forest on the highlands of British East Africa, and much better than that on the Nilgiri Mountains of India. In all these countries the New Zealand class of forest is being preserved by the Governments concerned.

Returned Soldiers.—The repatriation of returned soldiers is mentioned here (p. 108); their military organization on the European model and the inclusion of "returned soldiers of the Empire" are discussed later under "Forest Policy." An invitation to British soldiers for employment in forest-development and forest-settlement would furnish a peculiarly good stock of immigrants, since they would all be men passed medically. The official statement recently issued by the New Zealand Lands Department shows that in addition to land obtained by the subdivision of existing estates 323,343 acres of Crown land have been set apart for returned soldiers. Since the war began 554,534 acres of Native land have been purchased, and 700,000 are under negotiation—much of this land in the great virgin forests of the Urewera country, stated recently by the Hon. W. H. Herries to amount to 644,566 acres, and popularly to 2,000,000 acres. But over all this good work hangs the dark shadow of *alienation without forest demarcation*, the degradation or loss of natural resources and of prospective population, following the destruction of good forest on poor mountain soil.

It should be noted that three Australian States have already begun the employment of returned soldiers on forestry, two with funds provided for the purpose of the Federal Government; while the London *Times* of the 10th July, 1918, reports Mr. Prothero's statement to the House of Commons that arrangements were already in hand for employing disabled soldiers and officers on the new £15,000,000 scheme for British forestry after the war.

Reading the history of New Zealand, it is difficult to discern that the country has ever been called upon to face so serious an issue as that now before it in the forest question; for indiscriminate forest-destruction has gone so far that only a short further persistence in the present policy will render the restoration of the forests almost impossible at any reasonable cost. That will mean the final loss of the finest forests in the Southern Hemisphere, and with them the loss of an export trade worth, in the future, more than either wool or dairy-produce. It will mean the loss of land-settlement at the rate of one family per 75 acres, the bulk of this settlement being on the present "unoccupied third" of New Zealand. It will mean the loss of the best industry that New Zealand has ever possessed or is ever likely to possess, and the handicapping of two or three other industries in depriving them of their raw material at economical rates. It will mean a continued rise in the present high cost of living, for the destruction of all the accessible forest has already put New Zealand into so tight a corner that the people have to makeshift with a timber-use of less than one-sixth that of the United States of America, where only about half the houses are wood; and with a firewood-use (Railway returns) in New Zealand centres of population of only one-twenty-fifth that of the United States! Or, to take countries with no surplus forest, New Zealand has less than one-quarter the firewood-use of France and Germany; while the present consumption of sawn timber in New Zealand, with almost all the houses built of wood, is not much in excess of Germany, where it is only in a few country hamlets that one still sees any wooden houses.

The square issue before the country now is whether New Zealand is to have national forests (like nearly every civilized country but England, and as a result of the war England is now starting them), which will eventually bear more than the whole burden of the war debt, with all the indirect advantages that forestry brings in its train; or is the Dominion to pile up the enhanced liabilities of a country without national forests? Is New Zealand to have the forests of the most advanced countries of central Europe (see war-map, p. 188), or the forests of the long-misgoverned countries of Europe—Portugal, Spain, Italy, Greece, and Turkey? Is New Zealand prepared to pay a proportion of the £43,000,000 a year that England was paying for imported timber when the war broke out? ("Australian Forestry," p. 200). Or, even worse than that, to suffer the race-deterioration following rural depopulation that the visitor sees only too plainly in the England and Scotland of to-day? Is New Zealand prepared to enter on the same path of national decay which inevitably follows rural depopulation? It must ever be remembered that the present population of breadwinners settled on the soil (agricultural and pastoral) averages little better than one per square mile (one per 602 acres—New Zealand Yearbook, 1915, p. 127). During recent years in New Zealand the towns population has gradually out-distanced the country population. State forestry would do much to restore the balance.

It has been seen how the national-forest estates of France, Germany, and central Europe have been built up, gradually improving the wild forest, by a process of carefully arranged fellings, by helping natural regeneration, and with road-making; planting only being done where necessary to supplement natural regeneration. In Baden (and its Black Forest), which, as shown above, may be taken as a model State for New Zealand to copy, the planting during recent years has averaged only 1 per cent. against 99 per cent. natural regeneration.

The late Kingdom of Prussia, with an area not greatly above the area of New Zealand and 24 per cent. of its surface under forest, the forest occupying the poorest land, had a net forest revenue when war broke out of £4,500,000 from State-managed forests. France, robbed of its best forests in the 1870 war, has a present gross forest revenue of about £1,250,000. These forest revenues are all clear profit; there is no debt on the forests, as with forest plantations. There has been some revenue from the forests ever since (about 150 years ago) they started putting the forests in order.

MNEMONIC.

State forests in Europe give good returns:
Four and a half millions net the Prussians,
One and one-fourth gross millions to pillaged France,
Not to mention each Hun State, the Swedes, and the Russians
For gross returns in each class of forest*—
Huns 24 millions, Japs 12, Swiss† 2 or 3 does it.

These European forest revenues are realized in the face of serious competition. There are competing forests on three sides keeping down the prices of timber to only about half present timber-prices in New Zealand. New Zealand has no such competition. On the contrary, it has the best softwood forest in the Southern Hemisphere, where the timber-market may be taken as being worth about £7,500,000 yearly. It is a rapidly rising market, and should prove a valuable outlet for New Zealand produce unless decadence in forestry at home and progress abroad should reverse the present balance of exports and imports.

The timber-market of the Southern Hemisphere is likely always to remain one of the best, because the bulk of the area is dry country—too dry for the economic production of timber on a large scale.

Plantations.—Plantations are discussed in Part II; however, to complete this summary it may be mentioned that up to date the Government timber plantations embrace a total area of 30,000 acres, formed at a cost of £387,960. As a general average figure this is £13 per acre, or, reckoning interest at 4 per cent. for forty years, about £65 per acre. There are deductions (contra-interest and thinnings) and additions (buildings, supervision, and more fire-lines), but as a generalization this figure, £65, may be taken as close enough. 30,000 × £65 = 1,950,000. Thus, in round numbers, New Zealand has sunk no less than £2,000,000 in these doubtful, and too often distant, plantations. As plantations of unproved exotic trees

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* Viz., Government, municipal, corporate, or private. † The Swiss returns are not precise like the German, but they are interesting as coming from so old a democratic country.

Plate XIX.

Mamaku Forest.

A good mixed forest now being worked and destroyed by the Railway Department.

[*To face p. 187.*

they carry a fivefold risk (p. 153), and they have not been formed on definite schemes drawn up beforehand. Thus about £1,300,000 has been sunk in the Rotorua group of plantations. These may be the best group of timber plantations in the Southern Hemisphere. They are full of interest, a splendid object-lesson; but a Government has to deal with cold facts. When there are first-rate native forests nearer to the railway, some actually on the railway (see Plate XIX), and when these can be worked into cultivated forests at a profit, or at worst a fraction of the cost of timber plantations, the question will arise, why were the Rotorua plantations, costing £1,300,000, not made where there are no native forests, and near markets, as at Auckland or Wellington, &c.? There is low-priced bush land and still unalienated land near both of these cities, where £258,640 (two-thirds of £387,960, the cash cost of the plantations) spent on roads and forest development, as in Europe, would have worked wonders, and given the country both valuable and well-placed forest estates. The present plantations, with timber maturing in about forty years, are estimated to furnish about the $\frac{1}{800}$ part of the timber required then.

On an area basis the Government timber plantations represent $\frac{1}{533}$ part of the normal forest area of New Zealand, taking that at 25 per cent. of the total area, the proportion in the most advanced countries of central Europe.

Thus, after sinking £2,000,000 in risky plantations of exotic trees, New Zealand has perhaps met about the $\frac{1}{500}$ part of its forest requirements, whether those requirements be reckoned by area or by bulk of timber!

The one plantation of native trees, 400 acres of Totara at Puhipuhi, was unsuccessful, and there are three reasons which might account for the failure. But it is doubtful if the native trees can ever be profitably planted in full plantations with the present cost of labour in New Zealand. It is this that makes the present-day forest position so critical. Unless there be an early change the fine native forests of New Zealand will be irretrievably lost, and the chance of paying the cost of the war with State forests similar to those of other countries will be gone for ever.

A serious social mistake has been made over the plantations. On the European plan of forestry plus farming, they should have provided settlement on the land and perpetual work for half the year to the extent of 500 settlers now and 1,000 in perpetuity hereafter. Instead of which they have been formed on the plan—if I may dare to mention it again—that forestry consists in cutting down one tree and planting another. The plantations have been formed with prison labour and casual labour, and the future left to take care of itself. Now seems the time to rectify with from 500 to 1,000 soldier settlers, *giving to each a house and small farm on rental and perpetual Government work guaranteed for half the year.*

To plant the normal (25 per cent.) timber area of New Zealand at £50 per acre would cost 16,000,000 acres × £50 = £800,000,000.

FOREST ALIENATION WITHOUT DEMARCATION

This is too important a subject to attempt to recapitulate. It is treated briefly in the preceding pages, and I beg that whoever reads this will turn to them. *Forest alienation without forest demarcation* (p. 1, "Australian Forestry") is the root of all that New Zealand has lost over forestry in the past and of all that it will have to pay in the future, for the mistakes of the past. Forest alienation without demarcation may be costing New Zealand now a yearly loss of from £1,000,000 to £2,000,000: the first figure from the point of view of good or restorable forest lost, the second figure from the point of view of cost of replanting. It is logical to add the two together and say that forest alienation without demarcation may be costing the country £3,000,000 yearly! These losses will come into effect at different dates according to the class of forest lost—in some noble virgin forests, to-day; in some, with the maturing of the first thinned-out forest, in from twenty to thirty years; in some, where there is replanting of quick-growing exotics, in about forty years; and in some at various periods up to 100 or 120 years, as the native forest matures when cultivated by foresters.

The Lesson of the War-maps.

A glance at any of the large-scale war-maps of central Europe reveals at once how New Zealand, in forest policy, instead of being amongst the advanced countries, has got among the backward nations! The Rhine Valley, with the great Essen works, dye-works, and chemical works (enabling Germany to feed itself), together with its long string of great cities, has often been quoted as the heart of industrial well-organized Europe. All this was pointed out to me once more as I journeyed through the country shortly before the outbreak of war. It was to the Rhine Valley that I was sent, as a boy, by the Indian Government to learn forestry. The Rhine Valley embraces many types of soil, from the fertile alluvial "loess," equal to the best in New Zealand, to poor mountain lands similar to New Zealand mountain lands in nearly the same latitude and climate. The population of the Rhine Valley is large: about 50 acres of State forest with a small home farm supports a family. Living is cheaper (out of the towns) than in any part of the civilized world known to me. About one-third of the whole area is occupied by highly cultivated forests. That proportion is the result of centuries of trial. It is the proportion of forest that gets most out of the land and enables the land to carry the maximum population. Whether in autocratic Germany or republican France, the result is the same. When the Germans took the fine forests of Alsace-Lorraine in 1871 the forest "working-plans" were continued with little change. They were part of the same story of maximum soil-production.

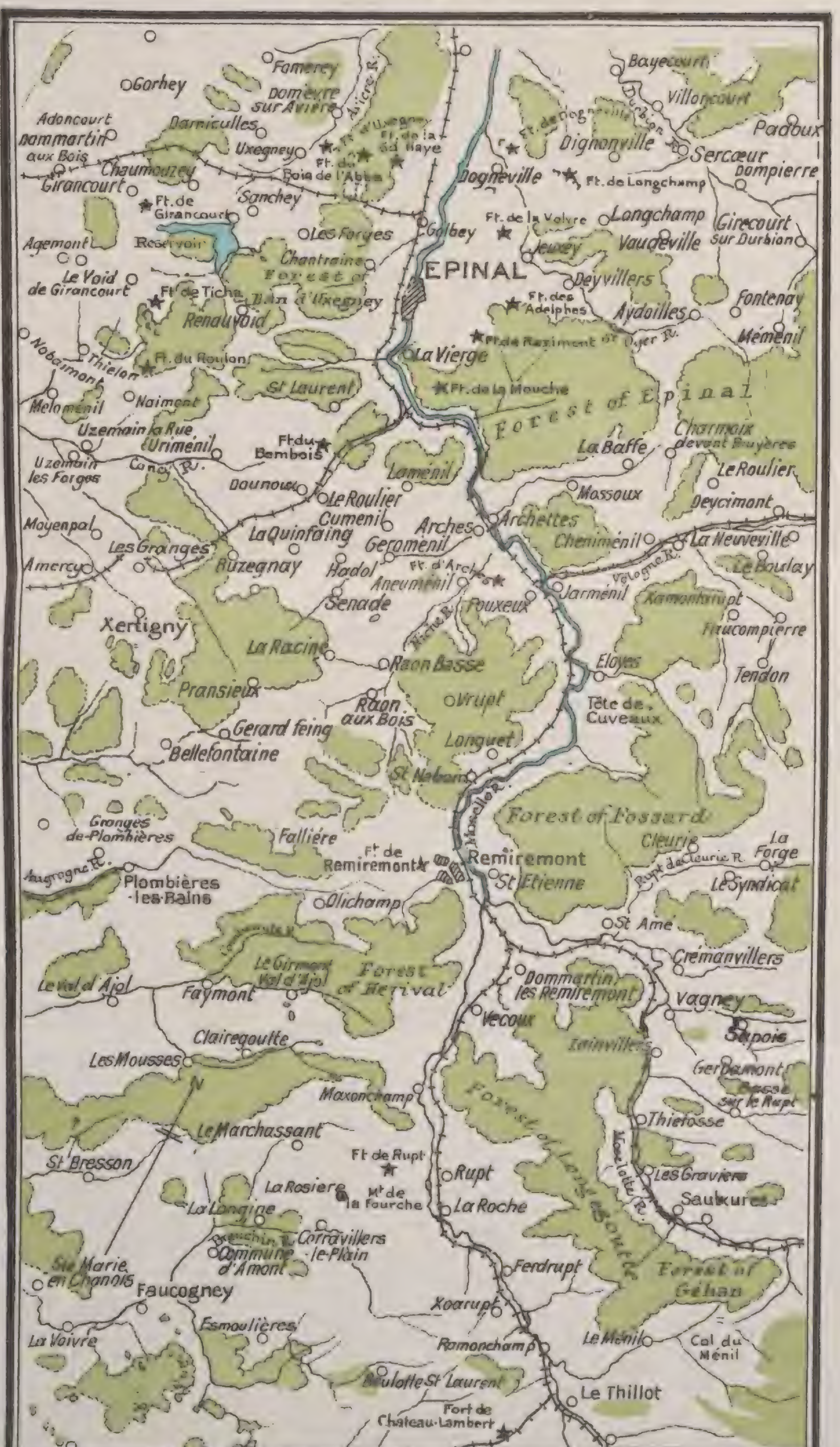
Two extracts from a large-scale war-map, a square taken from the country on each side of the Rhine—one from France and one from Germany—face this page.

It is noteworthy that the Rhine Valley has a carefully elaborated system of silviculture for its forests and strikingly economical living-costs, in its more remote forest valleys; while New Zealand has no silviculture and dear living. Though not completely cause and effect, the parallelism is worth noting.

National Forests for New Zealand.

A huge war debt faces the country. This must necessarily terminate the prodigal past. Valuable forest can no longer be destroyed for poor or uncertain grazing. No more millions can be sunk on doubtful plantations or amateur forestry. If a European State—Prussia—not much larger than New Zealand and less fertile can make £4,500,000 net yearly out of its State forests under skilled management (p. 186), New Zealand with every advantage on its side can do more. To consider

[From Phillips's War-map of Europe, showing distribution of forests.]

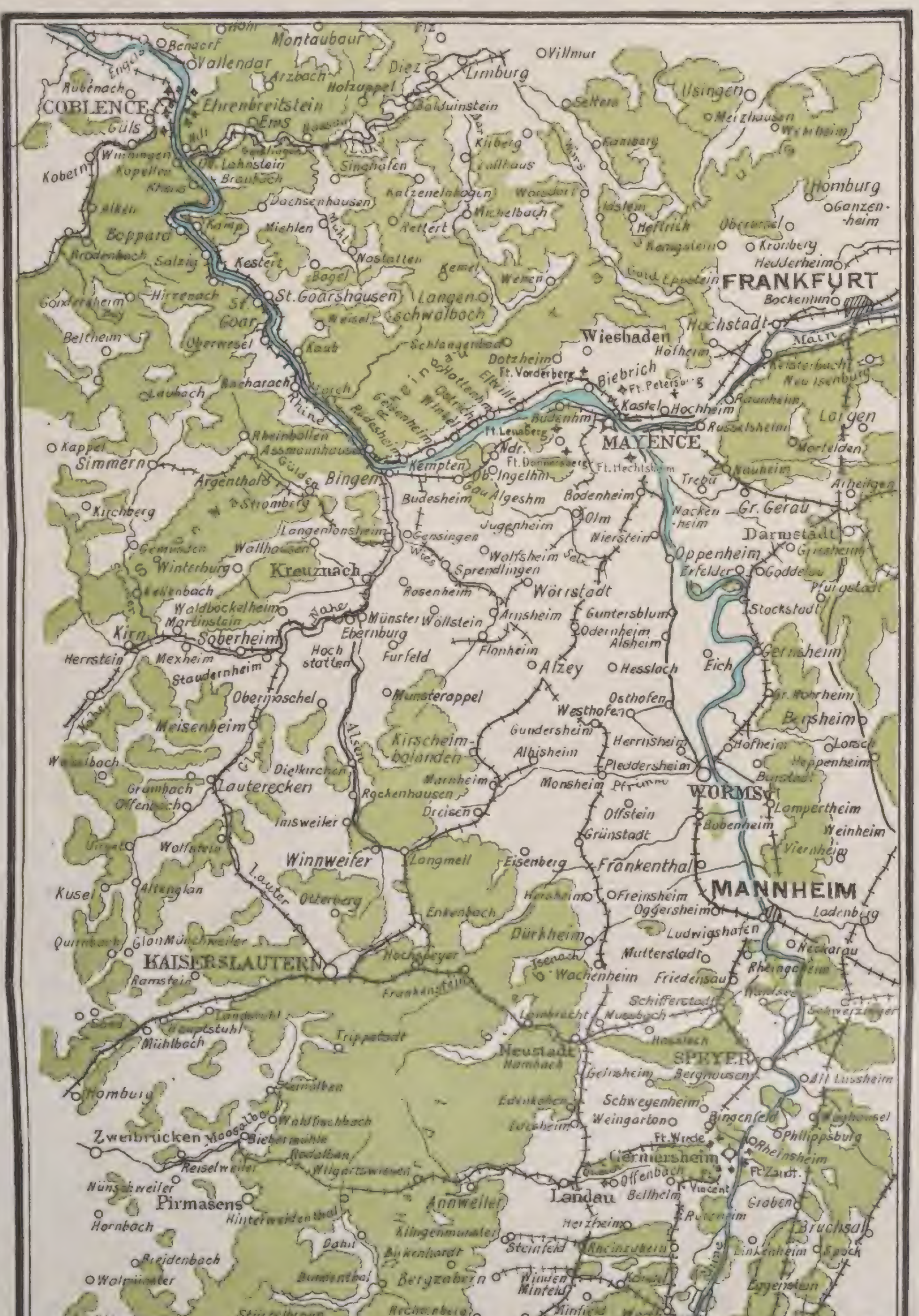


THE FRENCH SIDE OF THE RHINE VALLEY.

Spruce and Fir Forests of the Vosges Mountains.

Scale: 3 miles to an inch.

[From Phillips's War-map of Europe, showing distribution of forests.]



GERMAN FORESTS OF LOWER RHINE VALLEY.

Oak, Beech, and Scotch Pine.

Scale: 10 miles to an inch.

only the case of the Kauri forests, where the value of the timber is well known and where markets are assured, it is shown above that a half-million acres secured for the country now, by demarcation and redemption would pay all possible charges on the war debt.

The alienation of further good forests on poor or steep mountain land should be arrested without delay, and forest demarcation put in hand to finally separate the land best suited for forestry from that best suited for farming. To do the demarcation, and to work the forest estates as soon as they are formed, there should be a technical non-political Forest Department on the lines of the American Forest Service.

My father left a park to me, but it is wild and barren.

* * * * *

Yet, say the neighbours when they call, this is not bad but good land,
And bears in it the germ of all that grows within the woodland.

—TENNYSON.

DISCOVERY OF "KAIRARU."

Mr. Percy Smith, of New Plymouth, late Surveyor-General, has given me the following account of his discovery of Kairaru :—

"I was conducting the triangulation north of Auckland in 1870–74, and on one occasion was in advance of my men, they carrying the instruments and myself using my long knife to cut a track up one of the south-east spurs of Tu-ta-moe Mountain, when I saw (out of the corner of my eye, as it were), in a slight depression, what I took to be a cliff! But as I advanced a few paces I saw that I could look round it, and then it dawned on me that it was a Kauri tree of enormous size. I think one of the men measured the tree with his arm, and, at any rate, we came to the conclusion that it was just a chain (66 ft.) round. Some years afterwards I got Henry Wilson, then Crown Lands Ranger from Whangarei district, to visit the tree and measure it. This he did, and found it to be just 66 ft. in circumference."

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